



Infections Associated with Personal Service Establishments: Piercing and Tattooing

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Summary

- Piercing and tattooing are associated with bacterial and viral infections, typically localized to the pierced or tattooed site.
- Individuals with pre-existing heart conditions are at risk of developing infective endocarditis, a systemic infection involving the outer lining of the heart, when obtaining invasive procedures, such as piercing and tattooing.
- There is a lack of published literature on infections associated with body modification procedures, including scarring and branding.
- Poor infection control practices have been linked to outbreaks and individual cases of infection for both piercing and tattooing; these include use of contaminated sprays and moisturizers, improper cleaning and sterilization of tools, and re-use of tattooing ink between clients.
- Use of tap water to dilute ink or rinse needles between colour changes has been implicated in outbreaks of mycobacterium infections during tattooing.
- The majority of identified studies consists of case reports, which provide limited information on disease transmission risks for specific services.

Introduction

Personal Service Establishments (PSEs) are a growing industry that encompasses services such as piercing, tattooing, and body modification. These services can pose important public health concerns because they have the potential to transmit blood-borne pathogens to and between clients.¹ The specific infection risks will vary depending on the type of service and the conditions under which it is performed. A clear understanding of risks associated with these services can inform the development of health-protective regulations, guidelines, best practices, and programs.

Body piercing involves penetrating the skin's surface to create an opening or hole into which jewelry is placed or embedded, as with dermal implants. Common types of piercings include ears (lobes and cartilage), nose, tongue, eyebrow, navel, nipples, and genitalia. Tattooing involves the application of pigment into the skin in the form of a specific design. It is typically conducted with an electric tattoo machine which punctures the skin to insert pigment into the dermal layer.² Permanent makeup application is a type of tattooing service provided by some PSEs and involves the application of pigment into the upper layers of the skin (epidermis and upper dermis) to give the appearance of makeup.³ Pigment can be applied to the eyebrows, lips, eye lids, and cheeks, typically using a piercing gun.⁴ Body modification, which is defined as a deliberate altering of one's body for non-medical purposes, encompasses a range of invasive procedures, such as scarring (cutting a design into the skin), branding (burning a design into the skin), and stretching (permanently stretching parts of the body, such as the ear lobe).⁵

Aside from an understanding of general risks, little information is currently available on specific infection risks involved with such services. To help address this gap, we conducted a review of the scientific literature on infections associated with piercing, tattooing, and body modification services; infections associated with aesthetic services (manicures, pedicures, waxing services, hair styling, and barbering) are discussed in a previous paper.⁶

Piercing

We identified 1 case-control study, 1 outbreak investigation, 3 reviews, and 24 case reports (see Table 1). Bacterial infections were most commonly reported and were primarily attributed to *Pseudomonas*, *Streptococcus* and *Mycobacterium*. Only two studies reported potential piercing-related viral infections, hepatitis,⁷ and human immunodeficiency virus (HIV).⁸

Both Fisher et al. (2005)⁹ and Keene et al. (2004)¹⁰ found cartilage piercings to be at a higher risk for infection than earlobe piercings. Both Fisher et al. (2005)⁹ conducted a case-control study to investigate risk factors for cartilage piercings after an outbreak of *Pseudomonas* infections occurred in a New York county. By using the facility's client list of individuals who had received piercings between May and July 2003, researchers identified 15 cases and 61 controls. A standardized questionnaire was administered to study participants and swab samples from their piercings were collected. Authors found that receiving a cartilage piercing was an important risk factor for infection, with an odds ratio of 152 (95% CI: 8.42-2745). Keene et al. (2004)¹⁰ conducted an outbreak investigation after a physician alerted the health authorities about a possible outbreak. In total, 118 individuals were interviewed and those with an active infection had pus or wound swabs cultured for *Pseudomonas*; all had received a piercing at a particular mall kiosk in the previous 45-day period. In total, 186 ear piercings (defined as new holes) were conducted among the 118 patients (112 earlobe piercings, 63 cartilage piercings, and 11 ambiguous piercings). Seven (4%) piercings had laboratory confirmed *P. aeruginosa* infections, all of which were cartilage piercings. Cultures obtained from a disinfectant solution sprayed onto clients' ears and onto pre-sterilized jewellery were found to be positive for *Pseudomonas*; all other environmental samples were negative. Employees confirmed that cartilage piercings had been conducted with a piercing gun even though such a practice is prohibited in most jurisdictions, including the one in which the kiosk was located.

Several case reports have linked various types of piercings with bacterial infections (Table 1). Unfortunately, no site follow-up was conducted with the piercing facilities to identify potential

sources of infection transmission in any of these cases. We identified 4 reports of earlobe infections,¹¹⁻¹⁴ 7 reports of cartilage infections,¹⁵⁻²¹ 1 report each of an eyebrow and navel piercing infection,²² as well as one report of a tongue infection.²³ Additionally, we identified one case report of an infection of the hand, resulting from interdigital piercing²⁴ and one case of a subcutaneous dermal implant-related infection.²⁵ For nipple piercing related infections, we identified 1 review which looked at 12 cases,²⁶ as well as 3 additional case reports not included in the review.²⁷⁻²⁹ Javaid and Shibu (1999)²⁹ described the only case we identified of a breast implant infection resulting from a nipple piercing.

Aside from localized infections occurring at the site of the piercing, infective endocarditis (IE), a systemic infection involving inflammation of the lining of the heart, has also been reported. Body piercing is recognized by the medical community to be a risk factor for IE among those with pre-existing heart disease. Although the exact mechanism is not understood, it is hypothesized that infections are related to the colonization of bacteria around the jewellery after piercing and/or a localized infection by transient bacteremia introduced to the site during piercing. Armstrong et al. (2008)³⁰ reviewed 22 cases of piercing-related IE published between 1985-2007; infections were reported for tongue (7), ear lobes (6), navel (5), lip (1), nose (1), and nipple (1) piercings. Similarly, Toste et al. (2009)³¹ reviewed 24 cases of piercing related IE. Guillian et al. (2010)³² described a case of IE occurring from a nasal septum piercing, which was not included in the earlier reviews.

With respect to viral infections, we identified two reports of potential piercing-related infections. Johnson et al. (1974)⁷ reported on a follow-up conducted at a Washington State jewellery store after the health department received reports from a client that soiled instruments were being used; follow-up revealed that the instruments were blood soaked and treated only with a 70% alcohol solution. Following this incident, the health department investigated hepatitis cases within the country for that year (1972) and conducted a follow-up with 48 out of the 702 cases; the 48 had no known risk factors. Follow-up with the 48 cases revealed that 7 (15%) of the patients had received earlobe piercings prior to onset of their infection (varying from several weeks to over 6 months). Authors suggested that piercing was the likely cause of these infections but no further investigation was conducted to confirm this hypothesis. Lastly, Pugatch et al. (1998)⁸ discussed an HIV infection in a male patient with several risk factors for infection, one of which was receiving multiple body piercings.

Tattooing

Bacterial infections

The use of municipal water supply during the tattooing procedure has been suggested as the implicating source of two mycobacterium outbreaks.^{33,34} Kay et al. (2011)³³ described an outbreak of *M. haemophilum* involving two healthy males who developed infections after visiting the same Washington State tattoo parlour between August and October 2009; no other cases were identified. Follow up at the parlour found that the operator had followed the state's safety and sanitation standards. Authors hypothesized that mycobacteria had been introduced through municipal water used in a rinse solution during and after tattooing (most likely to rinse needles after colour changes) and also to dilute ink for shading. Environmental samples of the ink, tap water, liquid soap, petroleum jelly, equipment, soap dispenser, and black ink container were collected approximately 4 months after the initial infection; all samples were negative for mycobacteria. Drage et al. (2010)³⁴ described an outbreak in the United States involving 6 individuals who developed *M. chelonae* infections after receiving tattoos from the same tattooist

between October 2007 and May 2008. No follow-up with the tattooist was conducted but authors noted that in some cases municipal tap water, known to harbour mycobacteria, had been used to dilute black ink (to create grey pigment).

A second outbreak of *M. chelonae* was documented in France by Goldman et al. (2010)³⁵ when two tattooists were implicated after 48 patients suffered skin lesions around tattooed areas. Samples were collected of two opened and 1 unopened black ink bottles used by the tattooists. Cultures from both opened bottles were positive for *M. chelona* while the sealed ink bottle sample was negative. Interviews with the tattooists revealed that ink had been poured into smaller flasks and used either undiluted or were diluted with saline or tap water. The authors did not report on whether the small batches of ink were discarded after each use or reused between clients.

Long et al. (2006)³⁶ described an outbreak investigation involving 44 cases of skin and soft tissue infections of community-acquired methicillin-resistant *Staphylococcus aureus* (CA-MRSA). All patients had received tattoos from 13 unlicensed tattoo artists over a two-year period in three U.S. states. Some patients reported observing lesions, consistent with MRSA infections, on the tattooists' hands while others reported receiving tattoos in public places, such as parks or private residences; some tattoos were conducted with guitar-string needles and computer ink-jet printer cartridges. Interviews with 7 of the tattooists revealed poor adherence to infection control procedures. In most cases equipment was not cleaned, disinfected or sterilized; although tattooists wore gloves during tattooing, they were not necessarily changed between clients. No environmental samples were collected.

Several case reports discuss bacterial infection among individuals receiving tattoos (Table 2), including four cases of mycobacteria infections³⁷⁻⁴⁰ and two cases of *Pseudomonas aeruginosa* and *Streptococcus pyogenes*.^{41,42} No follow-up was conducted with the tattoo facilities in any of these cases. Some historical outbreaks and cases of tattooing-related tuberculosis⁴³ and syphilis⁴⁴⁻⁴⁶ infections were also found. Yuan et al. (2010)⁴⁷ described a more recent case of tattooing-related syphilis.

In their review of body art-related infective endocarditis (IE) cases between 1985 and 2007, Armstrong et al. (2008)³⁰ discussed a tattooing-related case in which a male received monthly tattoos over a 5-year period and was eventually diagnosed with this systemic infection. Invasive procedures, such as tattooing and piercing, are known risk factors for IE in individuals with pre-existing heart conditions. More recently, Tse et al. (2009)⁴² described a case involving a 44-year-old man with congenital heart disease who developed IE after receiving a tattoo at a local parlour in the United Kingdom.

Viral Infections

Several studies have found tattooing to be a risk factor for hepatitis C virus (HCV) and hepatitis B virus (HBV) infections. Delage et al. (1999)⁴⁸ conducted a case-control study to investigate HCV infections among 267 blood donors (confirmed to be anti-HCV-positive) and 1068 matched controls (anti-HCV-negative donors) in Canada. Multivariate analysis was conducted to assess the significance of tattooing and other risk factors, including: previous blood transfusions, intravenous drug use, acupuncture, ear piercing, previous surgery, exposure to insects, and accidental percutaneous blood exposure. Tattooing was found to be significantly associated with HCV infections with an odds ratio of 5.7 (95 % Confidence Interval, 2.5-13), along with four other risk factors. Researchers elsewhere have conducted similar case-control studies to identify tattooing as an important HCV risk factor among various groups, including blood donors

in the U.S. and Australia,^{49,50} patients in a U.S. outpatient clinic,⁵¹ the general public in Italy and Australia,⁵²⁻⁵⁴ and potential military recruits in Taiwan.⁵⁵ These findings are confirmed by a recent systematic review conducted by Jafari et al. (2010)² where a meta-analysis of 83 multi-national studies (published prior to November 2008) was conducted to investigate the association between tattooing and HCV. Results indicate that tattooing is associated with a higher risk of having an HCV infection, with a pooled odds ratio (OR) of 2.74 (95 % CI, 2.38-3.15). Authors calculated a higher OR for this association when analysis was restricted to only non-injection drug users (OR = 5.74, CI, 1.98-16.66). One study suggests that risk of HCV may increase with the number of tattoos received by an individual.⁵⁵ Researchers compared HCV risks between healthy tattooed men (n=87) and healthy non-tattooed men (n=126) in Taiwan, all of whom were non-intravenous drug users, and found higher risks for those with multiple tattoos; [odds ratio = 8.2 (95 % CI, 1.5-44.3)] compared to those with single tattoos [odds ratio = 5.9 (95 % CI, 1.6-22.0)]. Like HCV, risks of HBV infections among tattooed individuals are also expected to be higher.⁵⁶

Outbreak investigations have also linked hepatitis with tattooing. Limentani et al. (1979)⁵⁷ described an HBV outbreak in the United Kingdom. In total, 34 cases were identified; all had visited the same tattooist. Follow-up revealed that needles were not sterilized between use on multiple clients and instead were disinfected using a chlorohexidine solution, which likely resulted in the transmission of the virus between clients. Harrison and Noah (1980)⁵⁸ described an outbreak of HCV in the United Kingdom involving 37 individuals, 11 of whom had been tattooed within the previous 6 months. With respect to how tattoos were conducted, no further information was provided in the report.

Several case reports describe tattooing-related viral infections, apart from hepatitis, including *Molluscum contagiosum*,⁵⁹ human papillomavirus (HPV)-related warts,⁶⁰⁻⁶³ and HIV.⁶⁴ Prisons in particular have been suggested as important settings for tattooing-related HIV infections, due to both the high prevalence of tattooing among inmates⁶⁵ and unhygienic conditions, although some studies have also found no associations between tattooing and HIV infections risks among inmates⁶⁶ or the general public.⁶⁷

Permanent Makeup

Giulieri et al. (2011)⁶⁸ reported a mycobacterial outbreak in Switzerland, involving 12 female patients who developed infections after receiving eyebrow tattoos from the same freelance tattooist within an 8-month period. Ten patients had a microbiological diagnosis of *Mycobacterium haemophilum*, while two patients had diagnoses based on clinical presentation of lesions. Environmental samples were collected from oil, cold sterilizing agents and tattooing ink used by the tattooist. While oil and cold sterilizing samples were negative, 6 of 18 ink samples were positive for *M. haemophilum*. Authors suggested that use of contaminated ink between clients may have led to transmission of the infection to multiple clients. Hamsch et al. (2011)³ described a second mycobacterial infection outbreak involving seven women in Germany, all of whom received services from the same tattooist. A brown tattoo ink, which authors noted was imported, was positive for mycobacteria, in addition to other gram-negative bacteria which included *Ralstonia pickettii*. Authors suggested that contaminated ink was the source of infection but did not report on specific practices carried out by the tattooist which led to contamination of the ink.

Additionally, we identified one case of a *M. hemophilum* infection⁴⁰ and three cases of HCV infections,⁶⁹ potentially related to permanent make-up tattooing; no other risk factors were identified for all these cases and authors suggested that tattooing was the likely cause.

Discussion

Piercing and tattooing are both linked to important infection risks. Bacterial infections, particularly those involving *Pseudomonas*,¹⁰ *Staphylococcus*, as well as mycobacteria,^{22,70} are the most well-documented piercing and tattooing-related infections. Several types of piercings have been linked to bacterial infections, including ear lobe, cartilage, nasal, navel, and nipple piercings. Two studies identified cartilage piercings as a higher risk for infection, when compared with earlobe piercings.^{9,10} The use of a piercing gun, as well as spraying contaminated disinfectant on pre-sterilized jewellery, were implicated in an outbreak of *Pseudomonas*;¹⁰ both actions point to a lack of understanding of infection control on the part of the operators. Use of a piercing gun is prohibited in most jurisdictions because of the local trauma that it causes; increasing susceptibility to infection¹⁶ while spraying disinfectant onto pre-sterilized jewellery is a completely unnecessary step and, in this case, introduced bacteria to the piercing site. Use of poor infection control practices was also found to be an important contributing factor in several tattooing-related infection outbreaks.^{33,34,36,68} Few studies have conducted investigations to understand routes of infection transmission; among those that have been conducted, use of contaminated sprays,¹⁰ contaminated inks,^{35,68} and municipal water during the tattooing procedure have been identified.^{33,34} In particular, the practice of diluting inks and rinsing needles with municipal water between colour changes may be an important potential source of mycobacteria.^{33,34}

Piercing and tattooing are risk factors for a serious systemic infection (IE) among individuals with pre-existing heart conditions.^{30,31} Although physicians may recognize the risks that such invasive procedures pose, individuals who are susceptible to infection may not be aware of their health risks.⁷¹ In individuals with no known heart conditions, cases have also been identified after piercing and tattooing, indicating that not all risk factors for IE have been identified.³⁰ The link between IE and piercing and tattooing highlights the need for proper disinfection and sterilization procedures in PSEs, especially when the receiver may be susceptible to infections.

Gaps and Limitations

Many of the limitations of our review are summarized in a previous document.⁷² One major limitation is the lack of research studies on PSE related infections. For some services, such as body modification, no studies were found. Although information does exist for piercing and tattooing-related infections, the majority of these studies are case reports. While case reports provide some useful information, they rarely provide information on the pathways of infection transmission and risk factors, which is needed to develop health protective guidelines to limit the spread of infection. Additionally, case reports do not allow for a quantitative understanding of risk or burden of illness related to PSE services.

Although several case-control studies were identified for tattooing-related infections, much of this work was published before 2000. Tattooing practices have changed over time and older studies may not represent tattooing-related risks in current PSE settings. Information on

potential HIV-related health risks are limited to case studies or surveys, the majority of which have been conducted in prisons settings. Such studies may not be useful to inform tattooing-related risks in PSEs, since PSEs and prison settings are expected to differ regarding type of equipment and infection control procedures used, as well as additional risk factors present.

Finally, this review did not capture information gathered from local health units during PSE inspections; such information would be useful to compile but was outside the scope of our review.

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Appendix

Methods

The Ebsco database collection was used to search scientific literature using the following keyword terms, either alone or in combination: piercing, tattooing, permanent makeup, body modification, body art, branding, scarification, ear stapling, and tongue splitting. Word variants were considered along with outcomes for practices, such as infection and disease. No date restriction was imposed. Reference lists of studies were also searched to identify additional studies. We excluded studies investigating non-infectious health risks, including injury, allergic reactions, and respiratory hazards. In total, 66 studies were included in this review.

Table 1 Summary of studies of piercing-related infections

Authors	Type of Infection	Location of Piercing	Study Size	Comments
Case – control Studies				
Fisher et al. (2005) ⁹	<i>Pseudomonas aeruginosa</i>	ear cartilage	15 cases, 61 controls	<ul style="list-style-type: none"> Investigated risk factors for infection after outbreak was identified and linked to a particular facility; Cases defined as individuals who had been pierced at facility between May and July 2003 and developed an infection; controls defined as individuals without an infection who had received piercings at the facility over the same time period; Piercing location (i.e., ear cartilage) was found to be a significant risk factor with an odds ratio of 152 (95% CI: 8.42-2745).
Outbreak Investigations				
Keene et al. (2004) ¹⁰	<i>Pseudomonas aeruginosa</i>	ear cartilage	7	<ul style="list-style-type: none"> Researchers conducted active surveillance at local medical facilities and used media to encourage those with recent piercings from kiosk to obtain medical care; Swab samples were collected within 2 weeks of outbreak period; samples collected from countertops, plumbing fixtures, ear piercing guns; 3 employees and 1 owner were screened for <i>Pseudomonas</i>; 118 individuals who had obtained piercing within the previous 45 days were interviewed; 7 had confirmed <i>P. aeruginosa</i> infections; all were cartilage piercings; All piercings had been conducted with piercing gun; Use of disinfectant spray on ears and sterilized jewellery were contributing factors.

Case Reports				
Barkan et al. (2007) ⁷³	<i>Streptococcus viridans</i> (endocarditis)	navel	1	<ul style="list-style-type: none"> • 17-year old female with ventricular septal defect presented with fever, headaches, malaise for past month; diagnosed as infective endocarditis; • Occurred shortly after navel piercing; no local inflammation at navel site.
Cossette (1993) ¹¹	Unknown	ear cartilage	1	<ul style="list-style-type: none"> • 13-year old female presented with inflammation at piercing site 1 week after procedure; she was struck in the ear causing injury to the site; • Intravenous antibiotic treatment required.
Cumberworth et al. (1990) ²¹	<i>Pseudomonas aeruginosa</i>	ear cartilage	1	<ul style="list-style-type: none"> • 34-year old woman presented to outpatient clinic with infected outer ear 9 days after receiving piercing; • Ear piercing device was manually removed from ear after it failed to disengage properly during procedure; • Abscess had formed around the site and <i>Pseudomonas aeruginosa</i> was isolated from the pus; • Required reconstructive surgery.
Farah & Harmon (1998) ²³	Unknown	tongue	1	<ul style="list-style-type: none"> • 25-year old female presented with inflamed tongue within 1 week of obtaining piercing; • Swelling began within 6-8 hours of piercing and progressed within next 2-3 days.
Ferringer et al. (2008) ²²	<i>Mycobacterium</i> spp	eyebrow; navel	2	<ul style="list-style-type: none"> • Case 1: 12-year old female with eyebrow piercing presented with eyebrow lesion; medical treatment continued for 1 year; • Case 2: 22-year old female with infected navel piercing; piercing removed after 1 week; • Both are rarely reported piercing complications.
Fiumara and Capek (1982) ²⁸	<i>Neisseria gonorrhoeae</i>	nipple	1	<ul style="list-style-type: none"> • 27-year old male presented with pain in left breast; • One week prior had received nipple piercing from his roommate; • Examination revealed abscess at site; outpatient treatment with oral antibiotics.
Giulian et al. (2010) ³²	<i>Staphylococcus aureus</i> (endocarditis)	nasal septum	1	<ul style="list-style-type: none"> • 18-year old female admitted to emergency room with fever, nausea, malaise, difficulty walking; • Had received nasal septum piercing 6 months earlier; since then, no history of intravenous drug use, recent dental procedures or cardiac abnormalities; • Blood cultures were positive for <i>S. aureus</i>; echocardiogram showed mitral vegetation growth; • Had no known pre-existing heart conditions.

Hanif et al. (2001) ¹⁷	Unknown	high ear (cartilage)	3	<ul style="list-style-type: none"> • Case 1: 16-year old male presented to emergency room (ER) with inflamed outer ear; had received piercing 2 days earlier; • Case 2: 21-year old female presented at nose, ear, throat department with extensive perichondritis of right ear 1 week after receiving piercing; • Case 3: 23-year old female presented with multiple abscesses at multiple piercing sites; • No cell cultures collected.
Horii & Jackson (2010) ⁷⁴	<i>Mycobacterium fortuitum</i>	ear (tragus)	1	<ul style="list-style-type: none"> • 18-year old female referred to dermatology clinic due to abscess formation along jaw; piercing had been conducted 6 months earlier; • Discoloration around pierced site developed within 1 month; • <i>Mycobacterium fortuitum</i> was isolated from tissue culture; • Required four months of antibiotic treatment.
Javaid & Shibu (1999) ²⁹	unknown	nipple	1	<ul style="list-style-type: none"> • 40-year old female presented with cellulitis (infection of connective tissue) of the nipple and inflamed breast 2 weeks after receiving a nipple piercing; 6 months prior to piercing, patient had undergone surgery for breast implants; • Infection had spread from the nipple to the breast implant; • Authors suggest that individuals with breast implants should consider refraining from obtaining nipple piercings; • First reported case of a breast implant infection resulting from a nipple piercing.
Lewis et al. (2004) ⁷⁵	<i>Mycobacterium fortuitum</i>	nipple	1	<ul style="list-style-type: none"> • 29-year old female presented with infected nipple; • Piercing occurred 4 months earlier; piercing was closed at time of medical exam; • Authors noted <i>Mycobacterium</i> breast infections are uncommon; reported in one other study.⁷⁶
Lovejoy & Smith (1970) ¹⁴	<i>Staphylococcus aureus</i>	ear lobes	3	<ul style="list-style-type: none"> • Ear piercings conducted in non-PSE settings; • Case 1: 15-year old male presented with upper abdominal pain and high fever; patient's ear lobes had been pierced by a neighbour 5 months earlier; ear piercing was the only potential source identified; required 5 week intravenous antibiotic therapy; • Case 2: 14-year old female presented with 1 week history of pain in groin and buttocks; ear lobes had been pierced 1 week earlier by a friend; ear piercing led to systemic infection; • Case 3: 2-week old infant presented at ER with fever and loss of appetite; mother had pierced infant's ears 2 days prior using a needle and Listerine for disinfection; treatment required intravenous antibiotics.

Manca et al. (2006) ¹⁶	<i>Pseudomonas aeruginosa</i>	ear cartilage	1	<ul style="list-style-type: none"> • 21-year old female received an upper ear cartilage piercing with a piercing gun while on vacation in Thailand; swam in lake after the piercing; • Visited Canadian physician with infection 3 weeks after piercing.
Modest & Fangman (2002) ²⁷	Unknown	nipple	1	<ul style="list-style-type: none"> • 20-year old female with infected nipple piercing; • Received piercing 3 weeks prior to presentation; • No cell culture collected.
More et al. (1999) ¹⁸	<i>Pseudomonas aeruginosa</i>	high ear (cartilage)	2	<ul style="list-style-type: none"> • 2 patients presented at paediatric ER with abscesses at cartilage piercing sites; • Case 1: 14-year old female received piercing 4 weeks prior to presentation; • Case 2: 15-year old female received piercing with a piercing gun, 3 weeks prior to presentation.
Morgan (1952) ¹³	<i>Tubercle bacilli</i>	ear lobe	1	<ul style="list-style-type: none"> • 18-month old girl admitted to hospital with infection; • Had received earlobe piercings from her mother 2 months prior; mother had used a needle and thread; • Mother hospitalized for active pulmonary tuberculosis 1 month after conducting piercing.
Pugatch et al. (1998) ⁸	HIV	multiple	1	<ul style="list-style-type: none"> • 35-year old homosexual male received piercings over a period of several years in multiple locations, including Amsterdam, New York City, and Boston; • Acquired HIV infection but cause was unknown; authors suggested piercing might be cause of transmission.
Sandhu et al. (2007) ¹⁵	<i>Pseudomonas aeruginosa</i>	high helical ear	1	<ul style="list-style-type: none"> • 11-year old female diagnosed with severe auricular perichondritis; • Had received a piercing at a hair salon 11 days before presentation; returned to salon 4 days later for haircut; • Potential sources of infection were identified as: piercing gun, disinfectant solutions, and hair cutting spray water gun; • <i>P. aeruginosa</i> cultures were isolated from the water gun.
Schoffl et al. (2008) ²⁴	Unknown	Interdigital (hand)	1	<ul style="list-style-type: none"> • 21-year old female presented with infection 2 weeks after receiving interdigital piercings in her hand; • Infection required surgical treatment.
Staley & Fitzgibbon (1997) ¹⁹	<i>Pseudomonas</i> and <i>Staphylococcus</i>	high ear (cartilage)	2	<ul style="list-style-type: none"> • Case 1: 14-year old girl presented with infection 2.5 weeks after receiving piercing; admitted to hospital after swelling, erythema, tenderness developed at site; • Case 2: 16-year old girl presented with infection 2 days after receiving cartilage piercing.
Trupiano et al. (2001) ⁷⁶	<i>Mycobacterium abscessus</i>	nipple	1	<ul style="list-style-type: none"> • 17-year old female presented with 2 month history of inflammation of right breast; diagnosed as <i>M. abscessus</i> infection; Nipple piercing occurred 1 year prior to presentation of infection.

Turkeltaub et al. (1990) ¹²	<i>Pseudomonas aeruginosa</i>	ear lobes	1	<ul style="list-style-type: none"> • 22-year old female presented with pain in right ear; treatment required hospitalization; • Had received ear lobe piercings at the mall 2 days earlier.
Widick and Coleman (1992) ²⁰	<i>Pseudomonas</i>	ear cartilage	1	<ul style="list-style-type: none"> • 20-year old woman presented at ER with inflammation of ear 2 weeks after receiving piercing; Treatment required drainage of liquid at site and oral antibiotics.
Williams & Southern (2005) ²⁵	<i>Unknown</i>	Dermal implants (multiple)	1	<ul style="list-style-type: none"> • 37-year old man visited clinic after 15 of his 71 dermal implants were infected; • The 71 implants were obtained over a 3-year period; • Infected implants were removed and infection was treated with intravenous antibiotics; • Patient later decided to have all implants removed.

Table 2 Summary of studies of tattooing-related bacterial infections

Authors	Type of Infection	Study size	Comments
Outbreak Investigations			
Drage et al. (2009) ³⁴	<i>Mycobacterium chelonae</i>	6	<ul style="list-style-type: none"> All 6 cases had received tattoos by 1 tattooist; all developed skin infections within 1-2 weeks of tattooing; Infections were localized to grey areas of tattoos; Environmental samples were obtained from new ink bottles (black, grey, white), transfer gel, green soap, alcohol, cold sterilant, and water; all were negative for <i>M. chelonae</i>; Tattooist had discarded the original supply of gray ink; unavailable for testing.
Goldman et al. 2010 ³⁵	<i>Mycobacterium chelonae</i>	48	<ul style="list-style-type: none"> Skin infections occurred in 48 patients within 3 - 35 days of receiving tattoos from 1 of 2 tattooists; Same strain of <i>M. chelonae</i> was identified in skin swab samples collected from 13 of 30 patients; <i>M. chelonae</i> was also isolated from samples collected from open bottles of black ink.
Giulieri et al. (2011) ⁶⁸	<i>Mycobacterium haemophilum</i>	12	<ul style="list-style-type: none"> 12 females developed a localized infections over an 8-month period; Infections traced back to a single tattooist who had conducted permanent makeup tattoos on all 12 women; Environmental samples were negative for mycobacteria, except for 6 of 18 ink samples; Authors suggested that same batch of contaminated ink was used on multiple clients.
Hamsch et al. (2011) ³	Mycobacteria	7	<ul style="list-style-type: none"> Infection developed in 7 females, all of whom had received permanent makeup tattoos from single tattooist; Ink samples were positive for mycobacteria as well as other organisms.
Kay et al. (2011) ³³	<i>Mycobacterium haemophilum</i>	2	<ul style="list-style-type: none"> Case 1: 44-year-old healthy male developed a painless rash at the site 3 days after receiving tattoo; Case 2: 35-year-old male developed skin infection after visiting same tattooist as Case 1; Follow-up at the tattoo parlour revealed no deviations from safety and sanitation standards; Municipal water was used as a rinse and to dilute ink for shading; All environmental samples from the parlour were negative for mycobacteria, including tap water samples.
Long et al. (2006) ³⁶	Methicillin-resistant <i>Staphylococcus aureus</i>	44	<ul style="list-style-type: none"> Infections occurred in 44 cases who had received tattoos from 13 unlicensed tattooists in Ohio, Kentucky, and Vermont over a 1-year period; Interviews with 7 tattooists showed that gloves were worn but other infection-control measures, such as changing gloves, hand hygiene, and disinfection of equipment were not followed; 5 patients reported seeing lesions on tattooists' hands at time of tattooing.

Case Reports			
Belote et al. (1928) ⁴⁶	Syphilis	2	<ul style="list-style-type: none"> Two cases of syphilitic papules on tattooed site (localized to blue and red ink).
Korman et al. (1997) ⁴¹	<i>Pseudomonas aeruginosa</i> and <i>Streptococcus pyrogenes</i>	6	<ul style="list-style-type: none"> Males developed infections after receiving traditional Samoan tattoos; 1 case developed septicaemia (blood poisoning) following tattooing; Traditional Samoan tattooing involves an instrument made from sharpened boar's teeth dipped in ink; no disinfection procedures were used.
Preda et al. (2009) ³⁷	<i>Mycobacterium chelonae</i>	4	<ul style="list-style-type: none"> 32-year old male presented with infection after recently obtaining large tattoos on his arm and leg; tattoo was acquired over 2-month period; Source of infection was traced to use of contaminated ink which had been used on multiple clients; Authors identified 3 additional patients with similar infections.
Ricciardo et al. (2010) ³⁸	<i>Mycobacterium abscessus</i>	1	<ul style="list-style-type: none"> 25-year old male developed infected tattoo (localized to grey pigments) 7-10 days following procedure; Patient's roommate also had similar reaction with new tattoo received from the same parlour; No follow-up was conducted at the parlour.
Tse et al. (2009) ⁴²	<i>Staphylococcus lugdunensis</i> (endocarditis)	1	<ul style="list-style-type: none"> 44-year old man with pre-existing heart disease noticed redness and weeping around recently acquired tattoo; Man sought medical advice after experiencing increasing fatigue, trouble breathing, as well as fever; Diagnosed as endocarditis and required pacemaker as part of treatment.
Wolf et al. (2003) ³⁹	Mycobacteria	1	<ul style="list-style-type: none"> 27-year old female developed localized infection at tattoo site; Tattoo received 3 months prior; No information on tattooing procedure was reported.
Wollina (2011) ⁴⁰	<i>Mycobacterium haemophilum</i>	1	<ul style="list-style-type: none"> 47-year old female developed infections after obtaining permanent makeup tattoos in Thailand; Infection treated with oral antibiotics.
Yuan et al. (2010) ⁴⁷	Syphilis	1	<ul style="list-style-type: none"> 26-year old Chinese male developed rash on red areas of 1-year old tattoo; Infection was thought to be transmitted through use of ink contaminated with saliva from the tattooist (used to dilute ink).

Table 3 Summary of studies of tattooing-related viral infections

Authors	Type of Infection	Study Size	Comments
Case – control Studies			
Balasekaran et al. (1999) ⁵¹	Hepatitis C virus (HCV)	58 cases, 58 controls	<ul style="list-style-type: none"> • Study investigated risk factors for hepatitis C virus (HCV) infections in patients of a gastroenterology clinic; • Subjects were selected based on positive test for HCV antibodies; no history of transfusion or injection drug use reported; • Tattooing was found to be significantly associated with HCV with an odds ratio (OR) of 5.9 (95% CI: 1.1–30.7), along with several other risk factors, including having a history of sexually transmitted disease, heavy alcohol intake, and needle stick exposure.
Delage et al (1999) ⁴⁸	HCV	267 cases, 1068 controls	<ul style="list-style-type: none"> • Association between HCV infection and risk factors in volunteer blood donors was investigated; • Cases were blood donors who tested positive for HCV infection and controls were blood donors who did not test positive for HCV; • Conducted multivariate analysis and found 5 risk factors were predictive of having an HCV infection: tattooing, previous intravenous drug use, having lived in a prison or juvenile detention center, previous blood transfusion, and sexual contact with an intravenous drug user; • Tattooing was associated with an OR of 10.3 (95% CI,6.9-5.4)
Ko et al. (1992) ⁵⁵	HCV	90 cases, 180 controls	<ul style="list-style-type: none"> • Association between tattooing and HCV was investigated in a group of healthy young men (age not specified) with and without tattoos; • Having a tattoo was associated with HCV with an OR of 5.9 (95 % CI,1.6-22.0); • Having tattoos at multiple sites was also associated with HCV with an OR of 8.2 (95 % CI,1.5-44.3); • Risk of HCV infection was higher for individuals who obtained tattoos from non-professionals.
Mariano et al. (2004) ⁵²	HCV and HBV	3562 cases, 7221 controls	<ul style="list-style-type: none"> • Investigated associations between hepatitis infections and several risk factors, including tattooing, using Italian surveillance data gathered between 1997 and 2002; • Cases were defined as HBV and HCV infections; controls were defined as hepatitis A infections; • Tattooing was significantly associated with HCV an odds ratio (OR) of 5.6 (95% Confidence Interval, 2.8-11.0); tattooing was not significantly associated with HBV infections.
Mele et al. (1995) ⁵³	HCV and HBV	8953 cases, 4789 controls	<ul style="list-style-type: none"> • Investigated associations between hepatitis infections and several risk factors, including tattooing, using Italian surveillance data gathered between 1985 and 1993; • Cases were defined as HBV and HCV infections, controls were defined as hepatitis A infections; • Tattooing was significantly associated with HBV and HCV infections with Ors of 4.27 (95% CI, 2.50-7.28) and 3.55 (95% CI, 1.93-6.53), respectively.

Neal et al. (1994) ⁴⁹	HCV	74 cases, 150 controls	<ul style="list-style-type: none"> Association between HCV infections and various risk factors, including tattooing, was investigated in blood donors; Cases were defined as donors who tested positive for HCV infection; controls were donors who tested negative for the infection; Tattooing was significantly associated with HCV infections with an OR of 8.3 (95% CI, 3.6-19.6).
Sebastian et al. (1992) ⁵⁶	HBV	200 cases, 200 controls	<ul style="list-style-type: none"> Cases (tattooed individuals) were matched for age, sex, and ethnicity to controls (non-tattooed individuals) to determine the prevalence of HBV carrier status in tattooed persons; Prevalence rates of the HBV antigen in tattooed participants was 19.5% compared to 9.0% in non-tattooed controls 9.0%.
Cross-sectional Studies			
Castro et al. (1998) ⁶⁷	Human immunodeficiency virus (HIV)	2059	<ul style="list-style-type: none"> Investigated risk factor in patients diagnosed with AIDS who had no previously identifiable risk factors (as reported to U.S. Centers for Disease Control); Investigated risk factors included sexual history, intravenous drug use, and receiving tattoos; No association was found between tattooing and HIV/AIDS infection.
Outbreak Investigations			
Harrison et al. (1980) ⁵⁸	HBV	37	<ul style="list-style-type: none"> An 18-year old diabetic male, who was later diagnosed with HBV infection, received a tattoo at a tattoo parlour; he was believed to be the source of subsequent infections;
Limentani et al. (1979) ⁵⁷	HBV	34	<ul style="list-style-type: none"> 31 of 34 cases were tattooed by the same artist; In the tattoo parlour, several transmission routes were observed: same set of tattoo needles were used throughout the day and not properly disinfected between clients, batches of ink were reused between clients, and the tattooist did not wash hands between procedures.
Meta-analyses			
Jafari et al. (2010) ²	Hepatitis C	n/a	<ul style="list-style-type: none"> Researchers reviewed case-control studies to determine relationship between tattooing and infection risks of HCV; Conducted a meta-analysis of 83 studies; Tattooing was significantly associated with HCV infections, with a pooled OR of 2.74 (95% CI, 2.38–3.1) for all subjects, and an OR of 5.74 (95% CI, 1.98-16.66) for non-injection drug users; Authors suggest that prevention programs aimed at reducing spread of infections be targeted to youth and prisoners.
Case Reports			
Abildgaard et al. (1991) ⁷⁷	HCV	1	<ul style="list-style-type: none"> 40-year old male suffering from lethargy and diarrhea for several weeks was diagnosed with HCV infection; Patient was tattooed by a travelling gypsy 2 months prior to onset of symptoms; No other risk factors were identified; Use of contaminated tattoo needles was suggested as the transmission route.

Baxter & Deck (1993) ⁶⁰	Human papilloma virus (HPV)	1	<ul style="list-style-type: none"> • 21-year old developed warts 1 year after receiving tattoo on his chest; warts were localized to black areas of tattoo; • Authors suggested that virus could have been inoculated through use of contaminated ink or needles.
De Giorgi et al. (2010) ⁵⁹	Molluscum contagiosum	1	<ul style="list-style-type: none"> • 30-year old healthy male developed lesions on tattoo site 20 days after receiving tattoo; • Serology tests were negative for syphilis, HBV, HCV, and HIV; • No follow-up conducted at the salon; • Inoculation of organism presumed to be through contaminated needle.
Doll (1998) ⁶⁴	HIV	2	<ul style="list-style-type: none"> • Two cases of HIV possibly transmitted through tattooing in prisons; • Tattooing was conducted with unsterilized needles in both cases.
Marshall et al. (2007) ⁷⁸	Herpes compunc tor um	1	<ul style="list-style-type: none"> • 30-year old male developed lesions on his left arm where he received extensive tattoos 3 days prior; • Single-use needles were used at the tattoo parlour; • <i>Staphylococcus aureus</i> was isolated from the lesions and vesicular fluid was positive for herpes simplex virus type 1; • No follow-up at the tattoo parlour was reported.
Miller et al. (1994) ⁶¹	HPV	1	<ul style="list-style-type: none"> • Patient had dozens of small warts confined to the black region of tattoo that was obtained 10 years earlier; • Authors suggested that the virus was inoculated through tattooing process.
Ragland et al. (1994) ⁶³	HPV	1	<ul style="list-style-type: none"> • 27-year old male inmate presented with infection along lines of his tattoo obtained 8 years ago by an amateur tattooist using a staple and ballpoint pen ink; • Several transmission methods were proposed: Verruca was on the patient's skin during the procedure, inoculation of the virus from the saliva used to mix the ink, contaminated ink, or contaminated instrument (staple); • Case suggests long latency period of virus.
Sun et al. (1996) ⁶⁹	HCV	3	<ul style="list-style-type: none"> • 3 Chinese females received cosmetic tattooing of eyebrows and eyelids; all had clinical onset of HCV infection symptoms; • No prior history of intravenous drug use; • Authors report that most beauty salons in China disinfect needles using 70% alcohol; sterilization techniques used less commonly.
Watkins (1961) ⁶²	HPV	1	<ul style="list-style-type: none"> • 21-year old man developed warts in black areas of his tattoo; • Warts appeared soon after tattoo was completed.

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