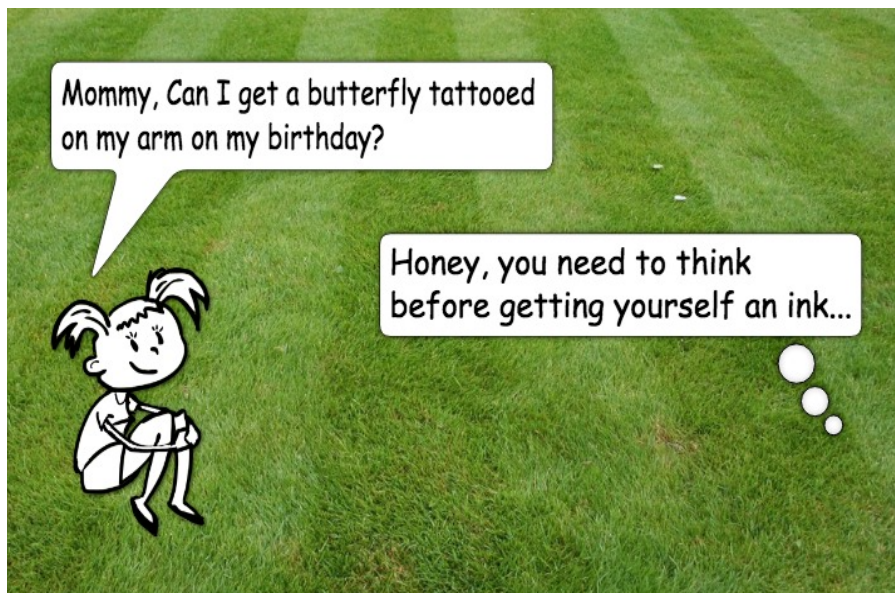


Tattooing and infection risk

Daisy: Mommy, can I get a butterfly tattooed on my arm on Sunday? It's my birthday!

Mommy: Honey! You need to think before you get yourself an ink...

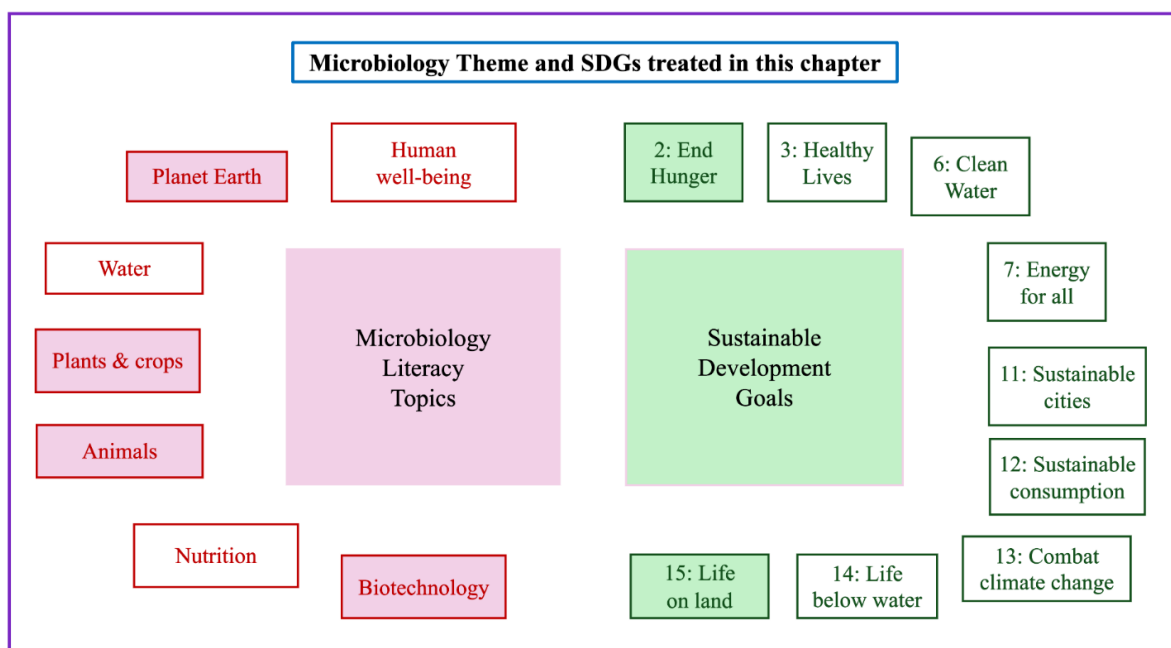


Jaspreet Kaur and Jasvinder Kaur

Tattooing and infection risk

Storyline

With the emergence of social media and over-the-top platforms (OTT) including Facebook, Netflix, Amazon Prime and YouTube, body modifications including hair colouring, body piercing and tattooing have gained immense popularity across the globe, especially among adolescents and young adults. Body tattooing is increasingly view as a symbol of self-expression and individuality in contemporary society. However, this freedom of expression is accompanied by several health risks and concerns associated with tattooing. Tattoos are permanent body modifications in which the ink is inserted into the dermis layer of the skin using electrically driven needles. During this procedure, the skin may suffer mild to severe damage, which may further lead to formation of blood clots. The problem may be further aggravated due to inadequate hygiene and poor sanitation practices in tattoo parlours, increasing the risks of microbial infections at the tattoo body site. Various microorganisms, including bacteria, fungi and viruses such as Hepatitis B and Hepatitis C, have been reported tp potentially enter the skin during the tattooing process. In addition, the use of infected needles significantly increases the risk of disease transmission. Therefore, there is an urgent need to understand the infection risks and safety measures associated with tattooing in order to curb the spread of infectious diseases, in alignment with Sustainable Development Goal 3 (SDG 3): “Good Health and Well-Being.”



The Microbiology and Societal Context and orientation

The Microbiology: Microbial contamination of Permanent Makeup (PMU) inks is a serious public health concern. The risk of acquiring bacterial or viral infections through tattooing largely depends on the of hygiene practices followed by tattoo parlours and tattoo artists. In addition, tattoo inks have been reported to contain infectious microbes capable of surviving in the unique azo dye-rich environment of the ink. Blood-borne diseases such as Hepatitis B, Hepatitis C, tetanus, and even AIDS may occur in severe cases where tattooing instruments or inks are contaminated (Figure 1).

The Societal Context: The Sustainable Development Goals (SDG), proposed by United Nation General Assembly, aim to provide a better and more sustainable future for all. Among these, **SDG Goal 3** focuses on ensuring ‘*healthy lives and promoting well-being for all at all ages*’. In this context, reducing the risk of infections associated with tattooing can significantly contribute to the protection of public health. This also aligns with ‘Target 3.9: which emphasizes “*Reducing illnesses and deaths from hazardous chemicals and pollution*’.



Figure 1: The objective of good health and well-being can be supported by reducing the use of unsafe inks on the body. The use of contaminated or unsafe inks may lead to infections and the transmission of diseases. The associated risks can range from allergies, scarring, granulomas to infections of varying severity.

Tattooing and infection risk: The Microbiology

Brief History of Body Tattooing

The term tattoo is derived from the Polynesian word ‘*tatau*’, which means to draw or to mark



Figure 2: The Konyak tribe resides in the Mon district of Nagaland. The Konyaks are notorious for their long-standing practise of headhunting during village attacks. Individuals who were successful in hunting heads received face tattoos, which were believed to make them appear more intimidating and masculine. Although the practice was outlawed a long time ago, a few formers head-hunters who are still alive can still be seen today. *From Wikimedia Commons*

Body tattooing is an ancient form of body art that dates over 5300 years in Europe, where the first mummified remains bearing carbon tattoos in the form of simple lines and dots were discovered. In 1992, the body of a tattooed man, estimated to be ~ 4000 -years old, was recovered from a glacier near the Austrian border. Body tattooing was also prevalent among Egyptians, where tattoos were often associated with rituals symbolized fertility, nobility and valour (Figure 2). This body art form gained popularity following the voyages of the British Explorer, James Cook and his sailors (1776-1779), after their arrival in Tahiti island, where tattooing traditions were deeply rooted. By the late 19th century, tattooing had become a fashion trend in England and other European countries. Even members of the royal families displayed tattoos as symbols of style and status (Messahel & Musgrove, 2009; Csesznek & Stemate, 2019). Over the past two decades, tattooing has expanded considerably worldwide, with younger people showing a greater inclination towards it (Quaranta et al. 2011; Kluger, 2015).

Health Implications Associated with Tattooing

Tattooing involves the injection of ink into the dermis of the skin using thin, pointed needles or similar equipment to create permanent body modifications. Approximately 1 g of ink may be injected per square centimetre of tattooed skin. Consequently, the foreign pigments present in tattoo ink can easily penetrate the underlying tissues beneath the skin. A relatively recent trend in cosmetic body modification is eyeball tattooing (Jenkins & Layton, 2016). Unlike corneal tattooing or keratopigmentation, which are medically performed in patients with corneal opacities, eyeball tattooing is generally carried out by non-ophthalmologists. In this procedure, tattoo ink is injected beneath the bulbar conjunctiva using a needle. The same dyes used for skin tattooing are also applied to the subconjunctival region. Such practices may increase the risk of severe ocular complications, including traumatic cataract, retinal detachment, vitreous haemorrhage, and subretinal haemorrhage. Patients may also develop infections such as orbital cellulitis and endophthalmitis (Duarte, 2017).

Approximately 20% of tattoo inks marketed as sterile have been reported to be contaminated. Contamination may arise from poor manufacturing and storage practices or from the use of non-sterile diluents such as tap water. Around 1–5% of individuals experience tattoo-related infections following the procedure (Laux et al., 2015). The use of non-sterile needles contaminated with bodily fluids (e.g., blood or saliva), repeated use of the same needle, and other unsafe practices significantly contribute to these health risks. Reusing contaminated needles greatly increases the possibility of infection. Additional sources of contamination include contaminated dyes, sponges, or tissues used to wipe away blood droplets during tattooing. These unsafe practices can result in mild to severe bacterial infections, including local infections such as erythema, abscesses, pustules, and tissue necrosis, as well as systemic infections such as toxic shock syndrome, septic shock, and bacteraemia (Figure 3). Tattoo inks may also trigger acute hypersensitivity or allergic reactions and may contribute to the development of both benign and malignant skin lesions (Nishioka, 2001; Dieckmann et al., 2019; Leijs et al., 2021).

Different bacteria isolated from tattoo-related infections (from blood, tissue, wound swabs, and/or abscess drainage) include:

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Bacteroides fragilis

Corynebacterium diphtheriae

Haemophilus influenzae

Klebsiella oxytoca

Methicillin-resistant *Staphylococcus aureus* (MRSA)

Moraxella lacunata

Mycobacterium chelonae

Pseudomonas aeruginosa

Serratia marcescens

Staphylococcus aureus

Streptococcus pyogenes

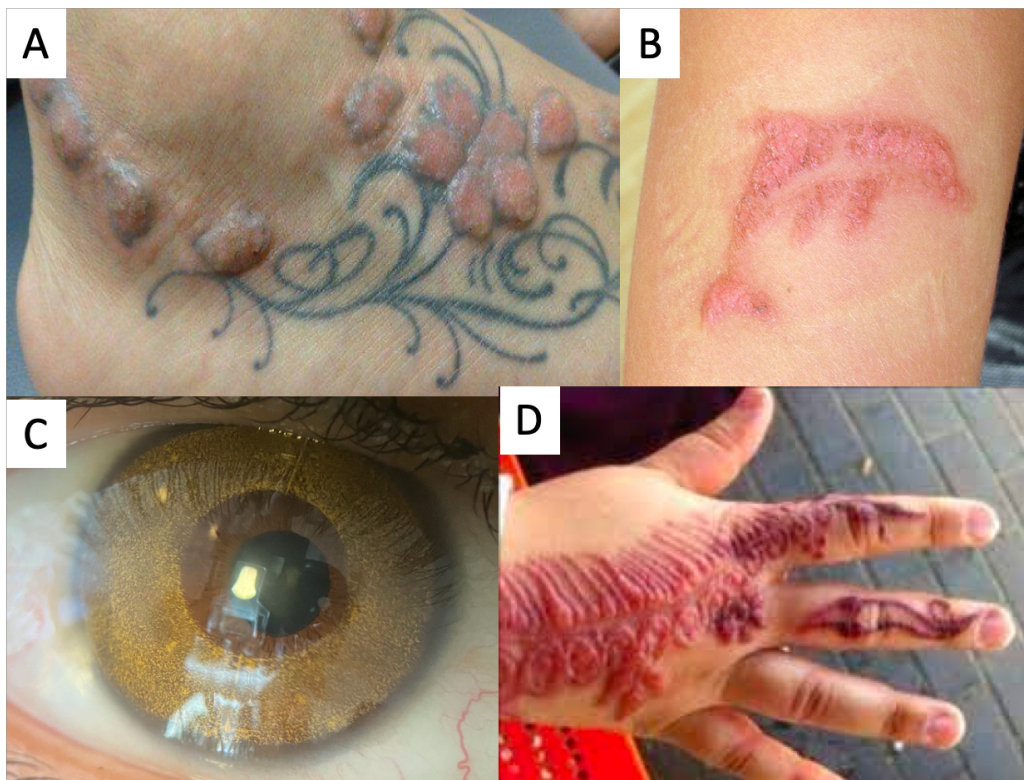


Figure 3: Tattoo-related skin conditions that may develop. A. The patient whose foot is shown here experienced complications from a tattoo for more than a year (Image credit: Courtesy of NYU Langone). B. Dermatitis caused by a temporary tattoo (dolphin) made with black henna (By Gzzz). C. Corneal tattooing with a honey-gold hue performed using a femtosecond laser (By Francis Ferrari). D. An illustration of a severe localized cutaneous reaction to temporary tattoos (Treister-Goltzman Y, 2016).

Tattooing related viral transmissions have also been reported (Nishioka & Gyorkos, 2001):

- human papillomavirus (HPV),

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- herpes simplex virus (HSV),
- hepatitis B virus (HBV),
- hepatitis C virus (HCV),
- human immunodeficiency virus (HIV)

In addition to bacterial and viral infections, tattoos have also been associated with fungal infections caused by organisms such as *Trichophyton rubrum* and *Epidermophyton floccosum*.

Tattoo Inks

The majority of tattoo inks consist of azo dyes (-N=N-), which are widely used in the textile, cosmetic, paper, and pharmaceutical industries. Other tattoo inks contain mixtures of polycyclic aromatic hydrocarbons (PAHs), which are genotoxic and capable of causing DNA damage. These inks generally contain insoluble pigments along with preservatives, dispersants, and other formulants.

Black tattoo inks are primarily composed of soot or carbon-based compounds, together with colouring agents such as titanium dioxide or iron oxide. Although there has been a gradual shift toward the use of organic tattoo inks, many still contain nanoparticles of heavy metals including titanium, barium, copper, aluminium, cobalt, and nickel. These dyes and their intermediates may be toxic and can adversely affect human health, potentially leading to mutagenic or carcinogenic effects. The harmful effects of azo dye-containing tattoo inks may be further aggravated by the presence of microorganisms within the inks (Bonadonna, 2015).

Case Studies

In 2016, Ralf Dieckmann and colleagues conducted a comprehensive investigation of cases reported between 1984 and 2015 that were associated with bacterial infections following body tattooing. They identified 67 cases, the majority of which involved severe bacterial infections and complications after the intradermal deposition of tattoo inks. Both systemic illnesses and localized skin infections, including septic shock, were documented.

Clinically significant levels of bacteria were frequently detected in tattoo ink bottles, regardless of whether the bottles had been opened or unopened. In this bacteriological study, aerobic mesophilic bacteria were identified in two out of 39 tattoo ink colours examined.

Relevance to Sustainable Development Goals and Grand Challenges.

The Sustainable Development Goals (SDGs) proposed by the United Nations General Assembly aim to ensure a better and more sustainable future for all. In particular, SDG 3 focuses on

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ensuring healthy lives and promoting well-being for people of all ages. In this context, preventing infection risks associated with tattooing is important for protecting public health. Major risk factors for tattoo-related infections include inadequate wound care and poor hygiene standards in tattoo parlours. Furthermore, commercially available tattoo inks may contain facultatively pathogenic bacterial species, which can pose significant risks to human health

Potential Implications for Decisions:

Individual Level

- Although getting a tattoo is a matter of personal preference, it should be carried out in accordance with proper hygiene practices to prevent the transmission of bacterial or viral infections (Figure 4). Individuals should be fully aware of both the benefits and drawbacks associated with of permanent tattooing.
- Awareness should be spread among relatives, peers, friends, and children regarding the possible health risks involved with tattooing, including the issue of microbial contamination in tattoo inks.

Community Level

- Tattoo parlours should strictly adhere to established safety guidelines and use tattoo inks that have been tested for microbial contamination.
- Community-based awareness campaigns should be organized to educate people about the safety measures that should be followed before getting a tattoo.
- Individuals should pay close attention to the hygiene and sterility standards maintained in tattoo parlours. They should ensure that needles are brand new before use and properly sterilized and disposed of according to established safety protocols.

National Level

- A nationwide safety procedure with clear regulations should be implemented and enforced across by all tattoo parlours, with penalties imposed for violations.
- Tattoo artists should be qualified professionals possessing appropriate training and licensing to perform tattooing procedures while following proper safety measures.

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- Safety protocols should include mandatory microbiological testing of tattoo inks before commercial distribution, as well as proper disposal procedures for used needles after tattooing.

Pupil participation

1. Class Discussion

- The adverse effects of tattooing
- Tattoos aftercare practices for individuals who choose to get tattoos (Figure 4)
- Microbial contamination of azo-dye rich tattoo inks
- Ingredients and sterility claims of commercial tattoo and permanent make-up (PMU) inks

2. Pupil Stakeholder Awareness

- Conduct a classroom exercise to test tattoo inks for microbial contamination using the plating method.
- Prepare a chart listing microbes isolated from tattoo inks along with the associated bacterial or viral infections.
- Purchase a few bottles of tattoo inks and examine them for intact packaging and proper sealing. Record the information regarding their ingredients, sterility claims, and expiration dates.

3. Class Experiment

To investigate bacterial contamination in tattoo inks

- Perform serial dilution of commercial tattoo and PMU inks. A group of 4 students may be given assigned different dyes such as Methyl Red, Toluidine Red, Sudan, Fast Dark Blue R Salt, Orange G, Ponceau BS.
- Plate the dilutions onto the agar plates (approximately 100 μ L) per plate. Tryptic Soy Agar (TSA) and Tryptic Soy Broth (TSB) may be used to observe bacterial growth.
- Incubate the agar plates at 37°C for 1-2 days.
- The bacterial colonies can be first identified based on their size, morphology, and colour, by streaking onto the same type of agar plates. Subsequently, 16S rRNA gene sequencing may be performed for accurate identification of bacterial strains.



Figure 4: It is essential to take proper care of your new tattoo to avoid infection. Individuals who decide to get a tattoo should always follow the advice of a dermatologist and adhere to all recommended aftercare instructions.

The evidence base, further reading and teaching aids

Bonadonna, L. (2015). Survey of studies on microbial contamination of marketed tattoo inks. *Curr Probl Dermatol*, 48, 190-195.

Csesznek, C., & Stemate, D. (2019). Tattoos as a form of expressing identity and perceptions of the health risks of getting tattooed. *Bulletin of the Transilvania University of Brasov. Series VII, Social Sciences and Law.*, 12(1), 59-70.

Dieckmann, R., Boone, I., Brockmann, S. O., Hammerl, J. A., Kolb-Mäurer, A., Goebeler, M., ... & Al Dahouk, S. (2016). The risk of bacterial infection after tattooing: a systematic review of the literature. *Deutsches Ärzteblatt International*, 113(40), 665.

Duarte, G., Cheja, R., Pachón, D., Ramírez, C., & Arellanes, L. (2017). Case series: Two cases of eyeball tattoos with short-term complications. *American Journal of Ophthalmology Case Reports*, 5, 26-28.

Jenkins, K. S., & Layton, C. J. (2016). An eye for art? A challenge of ophthalmic body modification. *Clinical & Experimental Ophthalmology*, 8(44), 741-741.

Kluger, N. (2015). Epidemiology of tattoos in industrialized countries. *Tattooed skin and health*, 48, 6-20.

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Laux, P., Tralau, T., Tentschert, J., Blume, A., Al Dahouk, S., Bäuml, W., ... & Luch, A. (2016). A medical-toxicological view of tattooing. *The Lancet*, 387(10016), 395-402.

Leijts, M., Schaefer, H., Rübber, A., Cacchi, C., Rustemeyer, T., & van der Bent, S. (2021). Cutaneous malignancies in tattoos, a case series of six patients. *Current Oncology*, 28(6), 4721-4737.

Messahel, A., & Musgrove, B. (2009). Infective complications of tattooing and skin piercing. *Journal of infection and public health*, 2(1), 7-13.

Nishioka, S. D. A., & Gyorkos, T. W. (2001). Tattoos as risk factors for transfusion-transmitted diseases. *International Journal of Infectious Diseases*, 5(1), 27-34.

Nho, S. W., Cui, X., Kweon, O., Jin, J., Chen, H., Moon, M. S., ... & Cerniglia, C. E. (2021). Phylogenetically diverse bacteria isolated from tattoo inks, an azo dye-rich environment, decolorize a wide range of azo dyes. *Annals of microbiology*, 71(1), 1-11.

Quaranta, A., Napoli, C., Fasano, F., Montagna, C., Caggiano, G., & Montagna, M. T. (2011). Body piercing and tattoos: a survey on young adults' knowledge of the risks and practices in body art. *BMC public health*, 11(1), 1-8.

Glossary

Abscess: A painful collection of pus, usually caused by a bacterial infection.

Azo-dyes: A broad group of synthetic dyes characterized by two nitrogen atoms (-N=N) linking carbon-containing compounds.

Dermatitis: A skin condition in which the skin becomes red, swollen, and sore. It is commonly caused by contact with irritants or substances that trigger an allergic reaction.

Erythema: Redness of the skin caused by increased blood flow to superficial blood vessels.

Hepatitis B: A viral liver infection caused by the hepatitis B virus (HBV). The virus can spread through contact with infected blood, semen, or other bodily fluids.

HIV: Human immunodeficiency virus, which attacks and weakens the body's immune system. If untreated, it can lead to acquired immunodeficiency syndrome (AIDS).

Mutagenic: Referring to any agent or factor capable of causing mutations, or changes, in the DNA of cells. Mutagenic substances may damage cells and contribute to diseases such as cancer.

Pustules: Small pimples or blisters on the skin that contain pus.

Septic shock: A severe and potentially life-threatening condition that may develop during sepsis, characterized by dangerously low blood pressure and inadequate oxygen supply to the body's organs.

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SDGs: The Sustainable Development Goals (SDGs) are global goals established by the United Nations to promote sustainable development, eliminate poverty and inequality, protect the environment, and ensure peace and prosperity for all.

Tattoo: A permanent design or pattern created on the skin by inserting ink into the dermal layer.