

# Tattoos and Liver Transplants: Exploring the Relationship and Implications for Policy

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## 1 Abstract

In an era marked by the increasing prevalence of tattoos and their evolving societal perception, this study investigates the role of tattoo parlors as potential contributors to nonalcoholic fatty liver disease (NAFLD). While well-established risk factors, such as obesity, type 2 diabetes, and high blood pressure, have been linked to NAFLD, the impact of tattoos and their associated complications on liver health remains relatively unexplored. Utilizing a multiple linear regression model and state-level data, our research aims to uncover the relationship between the density of tattoo parlors and liver health. This study calls for a more comprehensive understanding of the multifaceted risk factors associated with NAFLD, as the prevalence of tattoos continues to rise, and underscores the need for informed policy development to address this dynamic landscape.

## 2 Introduction

Nonalcoholic fatty liver disease (NAFLD) is a common form of liver disease and is often associated with obesity, type 2 diabetes, metabolic syndrome, and high blood pressure. These conditions are all linked to an increased risk of NAFLD and can contribute to the development of liver disease.

Obesity is a major risk factor for NAFLD, as it can lead to fat accumulation in the liver. In turn, NAFLD can progress to nonalcoholic steatohepatitis (NASH), which can eventually lead to liver cirrhosis and liver cancer. NAFLD is present in up to 75% of people who are overweight and in more than 90% of people who have severe obesity according to previous studies [1]. Type 2 diabetes and metabolic syndrome are also strongly associated with NAFLD, as they both can lead to insulin resistance and fat accumulation in the liver. Research suggests that one-third to two-thirds of people with type 2 diabetes have NAFLD [2]. High blood pressure is another risk factor for NAFLD, as it can damage the blood vessels in the liver and contribute to the development of liver disease.

In addition to these health conditions, tattoo parlors have also been suggested to be a potential risk factor for liver disease, including NAFLD. Tattoos involve puncturing the skin with needles, which can lead to the spread of blood-borne pathogens such as hepatitis B and C. Research approximated that up to 29.6% of individuals diagnosed with hepatitis B have NAFLD [3]. While most reputable tattoo parlors use sterile equipment and follow strict hygiene practices, there is still a risk of infection. Sterilization cannot account for the possibility of trace metals entering your bloodstream with the development of colored pigmentations/inks.

High concentrations of colorant ingredients are being pumped into thousands of people across the country. According to a recent survey “28% of tattooed individuals have more than four tattoos and 36% tattoos have tattoos, which are larger than 900 cm<sup>2</sup>” [4]. Therefore, several grams of coloring agents are being pumped beneath the skin. With all these unknown agents entering the body, researchers have observed links and hepatitis C which attacks the liver and could lead to cancer or cirrhosis. The results of Dr. Robert Haley’s, chief of epidemiology, study concluded that receiving a tattoo at a commercial parlor made an individual 9 times more likely to contract hepatitis C [5]. Hepatitis C has detrimental effects on the liver, and most people fail to consider the possible health risks associated with receiving a tattoo. Therefore, imposing restrictions on tattoo parlors is an important task for policy makers.

What was once seen as an exotic form of self-expression, tattoos have lost their rebellious image. They have become admired and its own unique art form for many professionals. With their recent upbringing, about 24 percent of the people in Western countries have tattoos as of 2019 [6]. The rise in popularity has prompted manufacturers to begin engineering and developing new inks

[7]. Now, many colors are available to use but these various pigments tend to be metal-based. There is concern that the concentration of chemicals in these inks could lead to health complications. In general, exposure to metals has been associated with liver damage. There is minimal information available about the toxicological risks of the introduced ingredients [8]. A rough estimation between 2.1 and 68 percent demonstrates how little is known about the adverse reactions to the latest ingredients [8]. While several problems may explain the typical need for liver transplant, studies suggest tattoos contribute to the total.

The relationship between these factors and liver transplants is complex and multifaceted. It is clear that obesity, type 2 diabetes, metabolic syndrome, and high blood pressure all increase the risk of liver disease and can lead to the need for liver transplantation. It is less clear whether tattoo parlors have a direct impact on liver transplantation rates, as the risk of liver disease associated with tattoos is not well understood. However, it is possible that tattoo-related infections could contribute to liver disease and the need for liver transplantation in some cases.

Overall, understanding the relationship between these risk factors and liver disease is important for developing effective prevention and treatment strategies. In this paper, we aim to identify another contributor to NAFLD in tattoos. By conducting a multiple linear regression, we suggest there may be potential grounds for instituting policies inhibiting access to tattoos.

## **3 Literature Review**

### **3.1 Current Statute**

In the United States, tattoo inks and their constituent pigments are subject to a unique regulatory framework. As stipulated by the U.S. Food and Drug Administration [9] and the Federal Food, Drug, and Cosmetic Act [21 U.S.C. § 361(a)], tattoo inks are classified as cosmetics under sections 601 and 602. Meanwhile, the pigments utilized in these inks fall under the category of color additives, regulated under section 721. Importantly, the use of color additives, with the exception of coal tar hair colors, necessitates the submission of a petition to demonstrate safety, adhering to the Code of Federal Regulations 21: 705 b.

‘Safe’ in this manner refers to the presence of “convincing evidence that establishes with reasonable certainty that no harm will result from the intended use of the color additive.” [10] It is crucial to recognize that tattoo pigments, formulated for injection into the skin, must comply with the Poison Prevention Packaging Act of 1970 and must not be misbranded. However, the classification of tattoo inks as cosmetics has specific implications, exempting them from pre-market assessment and clearance requirements [10]. Furthermore, the regulatory landscape surrounding ink composition, safety testing, and enforcement

primarily falls within the jurisdiction of local and state authorities.

The FDA only initiates investigations when formal complaints are made. This approach implies that regulatory actions are often triggered by specific concerns raised by the public or instances of adverse events. It is noteworthy that in the United States, the task of assessing the toxicological risks associated with tattoo inks rests with the FDA, specifically, the National Centre for Toxicological Research.

As the landscape of tattoo ink safety continues to evolve, the FDA assumes a role in disseminating relevant information to the public. In cases where potential risks or safety issues emerge, the FDA takes the responsibility of alerting the public, fostering a dynamic and responsive approach to the challenges posed by tattoo inks within the United States.

### **3.2 Potential Violation**

The chemical composition of tattoo pigments, characterized by their insolubility, hydrophobic properties, and molecular size, presents a significant challenge for researchers. Understanding the effects of tattoos lies in the limited knowledge of how ink particles are distributed within the body and organs post-tattooing. When tattoos are applied, damage to the skin initiates an immediate inflammatory response. Colorants from tattoo ink tend to accumulate in proximity to the application site, ensuring the enduring visibility of the tattoo or permanent makeup [11]. While some components of the ink mixture remain at the injection site, recent research findings suggest that remaining nanoparticles can enter the lymphatic system through the bloodstream. Moreover, it is plausible that these nanoparticles, along with potential impurities, may be transported and accumulated in larger organs within the body.

Considering these findings, it becomes apparent that the components of tattoo ink have the potential to be deposited in critical organs, such as the liver. The process of metabolism and excretion of ink components remains an area of limited understanding, primarily due to the scarcity of scientific research in this domain [11]. Consequently, it is imperative to delve deeper into the metabolic pathways and excretion mechanisms involved, as this knowledge could significantly impact our understanding of the long-term implications of tattoos on human health.

While there is a consensus of the health risks surrounding newly introduced pigmentations, the study determines the “introduction of security dossiers for tattoo colors with no-observed-adverse-effect level and acceptable daily intake values” [12] is a feasible way to use new colorants. Literature regarding any link between tattoos and liver transplants remains limited and ambiguous. Tattoos impose health risks that may severely damage the liver [13]. Notably, the meta-analysis study revealed a strong association between tattooing and hepatitis C

transmission. Other studies suggest that pigments that have been used in practice for several decades are safe to use [12].

### **3.3 Other Dangers**

In the context of adolescents in conflict with the law, the impact of tattoos on their lives is evident. A qualitative study of adolescent males detained in restrictive environments discloses information about the potential harms associated with tattoos. The study reveals how tattoos are interconnected with adverse experiences and consequences in this specific population.

The study identifies a strong correlation between tattoos and gang involvement, shedding light on the harmful effects of body art. Study participants revealed that tattoos often had emotional triggers, influencing them to get additional tattoos [14]. This observation highlights that tattoos can exacerbate involvement in criminal activity, which could lead to further legal conflicts and personal harm.

In addition to the psychological and emotional harm associated with tattoos, medical professionals face increasing skin reactions caused by tattoos. This emerging concern highlights the broader range of potential damage associated with tattoos. A common manifestation of damage is tattoo-induced allergic reactions.

The allergenic potential of tattoo inks arises from several components. Biodegradable components, such as natural dyes and preservatives, can cause allergic reactions that can heal with simple therapy. Over time, these components will naturally disappear from the skin, resulting in the resolution of allergy symptoms [15].

On the other hand, the presence of synthetic molecules and non-degradable dyes in tattoo inks requires invasive therapeutic measures. This includes procedures such as surgery, dermatome shaving, and, most commonly, laser removal therapy [15]. The need for such interventions highlights the potential harm associated with certain tattoo ink components and calls for a better understanding of their allergenic properties and effective treatment options.

This study can contribute to the previous literature by estimating the effect of tattoos on liver transplants. We use state as our unit of analysis, so we collect data at the state level.

Table 1: Descriptive Statistics

Variable	Mean (st. dev)	Minimum Value	Maximum Value
Liver Transplants	184 (238.97)	0	1084
Obesity	31.94 (4.04)	23.9	26.3
Diabetes	11.92 (1.62)	8.6	15.4
High Blood Pressure	33.78 (4.23)	26.3	44.1
Tattoo Parlors	602.06 (652.80)	56	3000

## 4 Methodology

### 4.1 Data

Liver transplant data was obtained from the Scientific Registry of Transplant Recipients (SRTR) which they collected from other organizations. SRTR manages and analyzes to create summary reports that are open to the public. The Organ Procurement and Transplantation Network (OPTN) is largely responsible for collecting the data in the OPTN database. Liver Transplant Centers | SRTR

The tattoo parlor variable was obtained from a platform that connects people to beauty and wellness services/professionals. Booksy contains the data used to determine the number of tattoo parlors in each city. The data is unkempt to be consistent with current businesses and is available from <https://booksy.com/en-us/s/tattoo-shops>. Table 1 below presents the descriptive statistics.

The CDC defines an obese individual as a person with a body mass index (BMI) greater than or equal to 30. BMI is calculated by dividing a person's weight in kilograms by the square of height in meters. While it does not measure body fat directly, it is an easy way to classify weight categories. Further, according to the CDC, "the American College of Cardiology and the American Heart Association published new guidelines for hypertension management and defined high hypertension as a blood pressure at or above 130/80 mmHg. Stage 2 hypertension is defined as a blood pressure at or above 140/90 mmHg."

Table 1 above shows that liver transplants across cities in this sample range from 0 in several states where there are no transplant centers to 1084 in California with an average of 184 liver transplant operations. Tattoo parlors varied from 56 in the District of Columbia to 3000 in California with an average of 602.06.

## 4.2 Model

To explore the potential relationship between tattoos and liver health, we obtained data from various sources. Liver transplant data was collected from the Scientific Registry of Transplant Recipients (SRTR), while information on the number of tattoo businesses on the state level was drawn from the Yellow Pages. Data on obesity, diabetes, and hypertension were obtained from the Centers for Disease Control and Prevention (CDC). We use a multivariate regression model, with the number of liver transplants as the explained variable and the causes of NAFLD, including tattoo parlors, obesity, diabetes, and hypertension, as the independent variables:

$$LiverTransplants = \beta_0 + \beta_1 TattooParlors + \beta_2 Diabetes + \beta_3 Obesity + \beta_4 Hypertension + \beta_5 Region + u$$

- *LiverTransplants* is the dependent variable, which we are trying to explain with the independent variables and measures the number of liver transplants conducted in a state.
- $\beta_0$  is the intercept or constant term, which represents the baseline level of liver transplants when all the independent variables are zero.
- Obesity, Type 2 diabetes, high blood pressure/hypertension, and tattoos (tattoo parlors are the proxy variable) are the independent variables, representing the causes of NAFLD.
- $\beta_1, \beta_2, \beta_3, \beta_4$ , and  $\beta_5$  are the regression coefficients, representing the effect of each independent variable on the number of liver transplants.
- $u$  is the error term, representing the unexplained variance in the number of liver transplants.

The inclusion of tattoo parlors as an independent variable in the model suggests that there may be a potential relationship between the prevalence of tattoo parlors and the number of liver transplants. However, it's important to note that using tattoo parlors as a proxy for tattoo prevalence may not be a perfect measure and should be interpreted with caution. Other factors related to the density of tattoo parlors, such as socio-economic factors or healthcare access, could also potentially affect the number of liver transplants. The regression coefficient  $\beta_5$  will help us understand the direction and strength of this relationship.

The model suggests that the number of liver transplants is expected to increase with increasing values of the independent variables. For example, if the prevalence of obesity increases, we expect to see an increase in the number of liver transplants. We can use this model to make predictions about the expected number of liver transplants given certain values of the independent variables.

Table 2: Regression Results

Variable	Growth Media			
	coeff	Std. err.	t	P t
<i>tattoo parl</i>	0.364	0.032	11.29	0.000
<i>diabetes</i>	8.693	24.210	0.36	0.722
<i>obesity</i>	1.746	10.177	0.17	0.865
<i>hypertension</i>	-9.859	12.153	-0.81	0.424
<i>west</i>	-49.186	65.858	-0.75	0.461
<i>south</i>	17.396	62.863	0.28	0.784
<i>northeast</i>	23.978	75.194	0.32	0.752
<i>cons</i>	159.357	192.91	0.83	0.416
$R^2$	0.8793			

## 5 Results

Regression results in Table 2 above show that tattoo parlors are an important determinant of city liver transplants. Higher numbers of tattoo parlors lead to more transplants. When the number of tattoo parlors increased by 1, the number of liver transplants increased by 0.36 (p-value<0.01).

## 6 Next Steps

### 6.1 Is it a cultural shift or just a proxy for something else?

The cultural shift towards the acceptance and popularity of tattoos is undeniable. Tattoos have transcended their countercultural origins to become a mainstream form of self-expression for people across various age groups and demographics. This shift is reflective of changing societal attitudes, where tattoos are no longer solely associated with rebellion but are now celebrated as a unique art form.

However, the relationship between the proliferation of tattoos and liver transplants is unlikely to be solely attributed to this cultural shift. While the growing acceptance of tattoos has led to an increased number of tattoo parlors, the link to liver transplants is likely mediated by underlying health-related factors. It is evident that the act of tattooing involves puncturing the skin with needles, which carries the risk of introducing bloodborne pathogens. Additionally, the composition of tattoo inks, which often includes metal-based pigments, raises concerns about their potential toxicological risks. These health-related factors create a more complex relationship between tattoo parlors and liver transplants, indicating that it is not merely a consequence of changing cultural norms.



## **6.2 Why do we see the relationship?**

The observed relationship between the proliferation of tattoo parlors and the occurrence of liver transplants can be attributed to several interrelated factors:

**Health Risks of Tattoos:** Tattoos, despite their popularity, are not without risks. The act of tattooing involves the introduction of needles beneath the skin, creating the potential for bloodborne infections. The association between tattoo-related infections and liver disease, leading to transplantation in severe cases, is a fundamental component of the observed relationship.

**Toxicological Risks of Tattoo Ink Ingredients:** Tattoo inks often contain metal-based pigments and other chemicals, the toxicological effects of which remain largely understudied. The presence of potentially harmful substances in tattoo inks and their long-term effects on the liver is a significant contributor to this relationship.

**Lack of Comprehensive Regulation:** The regulation of tattoo inks and practices varies significantly across different regions. Limited federal oversight results in variations in the safety of tattoo inks and practices, contributing to health risks. Many tattoos cannot be accounted for because they were not done at a parlor and performed by an unlicensed individual. This lack of comprehensive regulation is another factor that underscores the observed relationship.

## **6.3 Why is this happening?**

The relationship between the proliferation of tattoo parlors and the occurrence of liver transplants is happening due to the convergence of several factors:

**Increasing Prevalence of Tattoos:** The growing cultural acceptance of tattoos has led to a surge in the number of tattoo parlors. As a result, more individuals are getting tattoos, increasing the likelihood of exposure to associated health risks.

**Limited Public Awareness:** Many individuals may not be fully aware of the potential health risks associated with tattoos. This limited awareness can lead to inadequate precautions, delayed medical attention, and a higher incidence of tattoo-related infections.

**Delayed Recognition of Health Complications:** Some tattoo-related health complications, including hepatitis C transmission, may not manifest immediately. This delayed recognition can result in individuals seeking treatment or undergoing liver transplants at a later stage, contributing to the observed relationship.

## 7 Conclusion

This paper has delved into the multifaceted landscape of nonalcoholic fatty liver disease (NAFLD) and its potential associations with various risk factors, including the prevalence of tattoo parlors. The primary objective was to investigate the role of tattoo parlors as a potential contributor to NAFLD, while considering other known risk factors such as obesity, type 2 diabetes, and high blood pressure.

Our analysis revealed intriguing insights into the relationship between the quantity of tattoo parlors, serving as a proxy for tattoos, and the incidence of liver transplants. The results of our multiple linear regression model suggest a statistically significant positive relationship between the number of tattoo parlors and the number of liver transplants conducted in a state. This finding indicates that areas with a higher prevalence of tattoo parlors tend to experience a higher incidence of liver transplants.

While the direction of this relationship is apparent, the underlying mechanisms remain complex. Although the association between tattoo parlors and liver transplants is significant, it is important to interpret this relationship with caution. Other factors, not accounted for in our model, may contribute to this association. These could include socio-economic factors, healthcare access, and regional differences that impact liver disease prevalence.

This study has highlighted the need for further research to comprehensively understand the potential impact of tattoo parlors on liver health. Additional investigations should consider more granular data, such as the number of individuals with tattoos and the prevalence of complications associated with tattoos, to gain a more nuanced understanding of the relationship between tattoos and liver disease.

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