SAE./No.111/June 2018

Studies in Applied Economics

THE CASE FOR A MARKET FOR LIVERS

Nikhil Ramanathan

Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise

The Case for a Market for Livers

By Nikhil Ramanathan

About the Series

The Studies in Applied Economics Series is under the general direction of Professor Steve H. Hanke, co-director of the Johns Hopkins Institute for Applied Economics, Global Health, and the Study of Business Enterprise (hanke@jhu.edu). The working papers will fill gaps in the history, statistics and scholarship of the subject. The authors are mainly students at The Johns Hopkins University in Baltimore.

About the Author

Nikhil Ramanathan is a senior at Johns Hopkins majoring in public health studies with a minor in economics. He wrote this paper while serving as an undergraduate researcher at the Institute for Applied Economics, Global Health, and the Study of Business Enterprise during the summer of 2017. He graduated in May 2018.

Abstract

Liver transplantation is a necessary procedure to save the lives of thousands of people suffering from a multitude of diseases. Unfortunately, there are currently 14,301 individuals in the United States in dire need of a liver currently on the wait list, with more people added each year than removed as a result of successful transplantation. This is largely due to the National Organ Transplant Act of 1984's outlawing the compensation of donors for their organs, which, in concurrence with basic economic theory, has resulted in a vast supply shortage. This paper aims to assess the state of the organ transplantation system in the United States and make the case that compensation for organ donors will not only remedy the vast shortage, but would prove to be a more economical alternative than the status quo.

Acknowledgements

I thank Prof. Steve H. Hanke, Dr. Kurt Schuler, Dr. Sally Satel, and Dr. Shane Ottmann for their advice and guidance in writing this paper.

JELcodes: I11, I18

Introduction

The liver plays a crucial role in the human digestive system. Among other things, it is responsible for the production of bile, a fluid that aids in the digestion and absorption of fats, and the absorption of vitamin K, which is necessary for the production of blood-clotting factors. Liver enzymes break down proteins from food into their constituent amino acids so they can be used by the body (Maher 1997, 7). The liver also stores glycogen, vitamins, and minerals for other organs and decomposes harmful substances like alcohol and other toxins. All in all, the liver is responsible for up to 500 separate functions and produces over 1,000 essential enzymes and proteins. Needless to say, a well-functioning liver is critical for an individual's health and well-being.

Unfortunately, a number of diseases can impair or destroy liver function to the point that the liver is no longer capable of carrying out its many necessary tasks. Chronic viral hepatitis, alcoholic liver disease, acute liver failure, autoimmune hepatitis, nonalcoholic fatty liver disease, primary biliary cirrhosis, hepatic tumors, and several metabolic and genetic disorders are among the more common ailments that can render a liver defunct (Lucey 2014, 5). In such cases, when an individual's liver no longer functions well enough to keep him or her alive, a liver transplant is the only viable remedy.

Liver transplantation, also known as a hepatic transplantation, is a procedure in which a diseased or damaged liver is surgically removed and replaced with either a whole liver or, since the liver has regenerative capabilities, a portion of a healthy liver (Maher 1997, 7). The one-year survival rate after liver transplantation is about 88 percent for all patients, and the five-year survival rate is about 75 percent (Lucey 2014, 3). While, as with any surgical procedure, there are numerous associated risks and possible complications, liver transplantation is largely a safe and highly recommended procedure, especially considering that there is often no viable alternative for the patient's survival. Therefore, virtually all patients who suffer from liver diseases that are severe enough to threaten their lives choose to undergo liver transplants, which raises the question: where do the healthy livers come from?

Unfortunately for those who need them, livers cannot be bought and sold like most other goods in the United States. In 1984, the U.S. Congress passed the National Organ Transplant Act of 1984 (NOTA), which outlawed the compensation of organ donors and established the Organ Procurement and Transplantation Network (OPTN) to instead maintain a national registry for organ matching ("About the OPTN"). Because of this act, all solid organs, including livers, must be donated rather than sold. As such, as one might expect from basic economic theory, since the compensation that donors receive is anchored at zero, there exists a vast shortage of livers.

Because of the numerous possible risks and trade-offs associated with donating a liver and the liver transplantation process, it is no surprise that very few live donors are willing to simply give away chunks of their livers for free. However, some level of compensation for donating a segment of a liver would surely outweigh those downsides and provide a meaningful incentive for at least some people to donate to a stranger.

The purpose of this article is to investigate the characteristics of liver donations under the current allocation system, and consider how the characteristics of a free market for livers could benefit all stakeholders involved.

History of Organ and Liver Transplantation

While attempts at organ transplantation date back to ancient times, the practice saw rapid advancement during the twentieth century. Successful organ transplantation is not possible without vascular anastomosis, which involves surgically connecting blood vessels that were previously separate. This practice was pioneered by Alexis Carrel in 1902 with animals, and for which he was awarded the Nobel Prize for Medicine in 1912 (Azzam 2012, 1; Munshower 2000, 7).

The second major hurdle for successful transplantation is the possibility of immunological rejection. During World War II, British physicians on numerous occasions attempted to administer skin grafts to Royal Air Force pilots who were severely burned in plane crashes. They found that skin transplanted from another individual quickly began to die and would fall off within days of transplantation. Discoveries in the 1940s led to the understanding that the problem was due to an immune response that treated the transplanted organ as a foreign antigen. As a result, throughout the 1950s, advancements were made in successfully suppressing the immune response with various drugs, including cortisone therapy and 6-mercaptopurine (Azzam 2012, 2).

As a result of these advancements, as well as revolutions in surgical techniques and suture materials, Dr. Joseph Murray, an American plastic surgeon, performed the first successful organ transplant in 1955, transplanting a kidney between identical twin sisters (Azzam 2012, 2; Munshower 2000, 7). Successive advances in the procedure, specifically with regard to effective immunosuppressive therapy preventing a transplanted kidney from being rejected by the recipient's body, paved the way for liver transplantation among humans.

Meanwhile, in 1955, C. Stuart Welch experimented with transplantation of an auxiliary liver in mongrel dogs. In 1958, building on Welch's discoveries, Dr. Francis Moore described a standard technique of canine liver orthotopic liver transplantation (Azzam 2012, 2). (Orthotopic liver transplantation was the first kind developed; for a description of how it differs from other types, see the end of this section). In 1963, Dr. Thomas E. Starzl attempted the first human orthotopic liver transplantation in a 3-year-old boy, though the patient died during the operation (Azzam 2012, 2). However, despite the failure of the procedure itself, he was successful in creating an immunosuppressant drug therapy treatment to prevent organ rejection.

Prior to Starzl's development of immunosuppressive treatments, a total of 244 kidney transplantations were performed in the United States, though only 9 recipients survived for over a year after the procedure. Death was typically a result of the body's harsh rejection of the transplanted organ (Munshower 2000, 9). By the summer of 1964, thanks to Starzl's breakthrough, 200 kidney transplant centers around the United States were performing over 1,000 transplantations per year, with graft survival rates above 50 percent (Munshower 2000, 9).

In 1964, the first successful heart transplant took place and, after numerous subsequent attempts and the tweaking of both the process and technique, Starzl performed the first successful clinical liver transplantation in 1967 (Munshower 2000, 9-10).

In 1969, the U.S. Public Health Service gave contracts to seven hospitals around the country to establish organizations to procure cadaveric kidney donations and provided funding for a computerized allocation system (Weimer 2007, 18). The Social Security Act Amendments of 1972 extended Medicare coverage for either kidney dialysis or transplantation to patients with chronic renal disease through the ESRD program, and amendments to the Act in 1978 extended coverage for immunosuppressive drugs following transplants from one to three years (Weimer 2007, 18). However, at this point, only kidneys were successfully transplanted with high graft survival rates. Transplantation of vascular organs, such as the heart, lungs, and liver, which necessitate compatibility between the antigens of the transplanted organ and the antigens of the recipient's body, resulted in extremely low graft survival rates, unless the immune system was suppressed to such a degree that the patient was highly vulnerable to common bacterial and viral infections instead (Azzam 2012, 4; Munshower 2000, 10). At the time, 95 percent of transplant recipients of organs other than kidneys died within three months of the procedure (Munshower 2000, 10).

In 1981, however, Swedish drug-manufacturer Sandoz began clinical trials for cyclosporine-A, an immunosuppressant that allowed recipients to accept organ transplants but still fight off viral and bacterial ailments (Azzam 2012, 4; Munshower 2000, 10; Weimer 2007, 18). This breakthrough boosted one-year graft survival rates of kidneys by 35 percent and allowed more vascular solid organs such as hearts, lungs, and livers to be transplanted with greatly reduced risk of organ rejection (Munshower 2000, 11). As a result, liver transplantation became a widely accepted procedure and, in 1982, pediatric liver transplantation garnered widespread public attention after two parents successfully secured a liver donor for their 11-month-old son Jamie Fiske (Weimer 2007, 18). Between 1981 and 1984, the number of liver transplantation centers grew from 13 to 34 (Munshower 2000, 10). In 1983, Medicare coverage was granted for liver transplants. Soon enough, President Ronald Reagan, Speaker of the House Thomas O'Neill, and newscaster Dan Rather were among the many prominent figures who publicly endorsed pediatric liver transplantation, and used their media access and influence to assist particular families in seeking donors or financial support for their children with end-stage liver disease (Weimer 2007, 18).

With the growing pervasiveness of transplantation in the United States during the 1980s, Congress, led by Representative Albert Gore, Jr. (D-Tennessee) and Senators Orrin Hatch (R-Utah) and Edward Kennedy (D-Massachusetts), passed the National Organ Transplant Act of 1984 (NOTA) in an effort to prohibit preferential allocation of organs based upon ability to pay, as well as to replace the splintered allocation system then in place with a nationwide one that would unify organ allocation across various Organ Procurement Organizations (OPOs) (Weimer 2007, 18-20) (Sullivan 1983). The act called for the United States Department of Health and Human

Services to contract with a nonprofit, nongovernmental organization to provide for the establishment and operation of a privately administered network of OPOs to encourage safe and effective procurement of cadaveric organs as well as to coordinate their allocation. The network became the Organ Procurement and Transplantation Network (OPTN) that exists today (Munshower 2000, 16-17). In addition, the act prohibited commerce in organs by making it unlawful for any person to knowingly "acquire, receive, or otherwise transfer any human organ for valuable consideration for use in human transplantation if the transfer affects interstate commerce," in essence making it illegal for donors to be compensated for their organs (Weimer 2007, 19). In 1986, the Task Force on Organ Transplantation released a report that, among other things, strongly endorsed continued prohibition of commercialization of organs and argued for obtaining the consent from next of kin before the harvesting of cadaveric organs, pointing out that the donation of a cadaveric organ be should be considered an "altruistic act" as opposed to the sale of a commodity (Blumstein 1989, 27-28).

The Omnibus Reconciliation Act of 1989 required that all hospitals performing organ transplants be members of the OPTN and abide by its rules to receive payment under Medicare or Medicaid, essentially strengthening the network's status (Weimer 2007, 19-20).

Today, several different procedures for liver transplantation exist, including auxiliary liver transplantation, when a healthy liver graft is implanted in addition to the native liver; reduced-size liver transplantation, involving the resection of an adult cadaveric liver so it may fit inside the body of a child or infant recipient; split liver transplantation, allowing for a donated cadaveric liver to be split into two and implanted into two different recipients, regenerating in each body; and living donor liver transplantation, involving resecting a piece of a liver from a living donor and transplanting it into a recipient's body and allowing both to regenerate in each individual. Further research on the matter continues, with some researchers looking to hepatocyte and stem cell transplantation, in which a failing liver can itself be regenerated into a healthier one with cell implantation. However, all types of liver transplants fall under two broad categories: orthotopic liver transplantation, in which the host liver is removed from the body and replaced with a homograft, or a human liver from another individual, and auxiliary homotransplantations, in which the donor's liver is inserted at an alternate site while the original liver remains. Orthotopic transplantation is the far more common form of procedure (Starzl 1982).

Liver transplantation is now a very thoroughly researched procedure that is highly endorsed by the medical community worldwide. It has saved hundreds of thousands of lives, and continually proves to be a necessity for the survival of individuals of all ages and ethnicities suffering from a plethora of illnesses.

Liver transplant procedure

Many incremental improvements have been made to the field of surgical technique over the years. Orthotopic liver transplantation, which is by far the most common form of liver transplant procedure, is heavily focused on maintaining normal, stable blood pressure while achieving adequate vascular and biliary anastomosis (the surgical connection of blood vessels) and perfect hemostasis (the stopping of blood flow). The following are the steps in a typical orthotopic liver transplantation (Llado and Figueras 2004; “Abdominal incisions in general surgery: a review”):

1. Abdominal Incision: The most commonly used incisions are the bilateral subcostal incision with midline extension, frequently referred to as the Mercedes incision or Makuuchi incision, which entails cutting open the abdominal cavity several inches below and parallel to the lowest rib, allowing for adequate exposure to the liver for dissection.

2. Native Liver Removal: The next step is the cutting of the portal veins that convey blood to the liver from the other organs in the abdominal cavity, with most surgeons utilizing the “piggy-back” technique in which the inferior vena cava, a large and important vein that carries deoxygenated blood from the lower two-thirds of the body directly to the heart, is preserved. This technique is associated with better stability of blood pressure, lower blood transfusion requirements, and shorter time for surgery. All the hepatic veins are exposed with long enough venous cuffs for the subsequent connections between the blood vessels of the body and the implanted liver, and clamped, while avoiding clamping the caval vein. The native liver is then removed.

3. Vascular Anastamosis: Then, liver allograft begins. The donor’s upper vena cava is sutured to the cuff created with the three recipient hepatic veins. This is followed by the portal or arterial anastamosis. The “piggy-back” technique with a temporary portocaval shunt, which connects the portal vein, which accounts for 75 percent of the liver’s blood flow, to the inferior vena cava, allows the surgeon to choose the order of the graft. After the anastamoses are complete, the portocaval shunt is taken down.

4. Biliary Tract Reconstruction: A gall bladder removal, or cholecystectomy, is performed, after which the biliary tract reconstruction is performed so that the body is capable of storing and secreting bile.

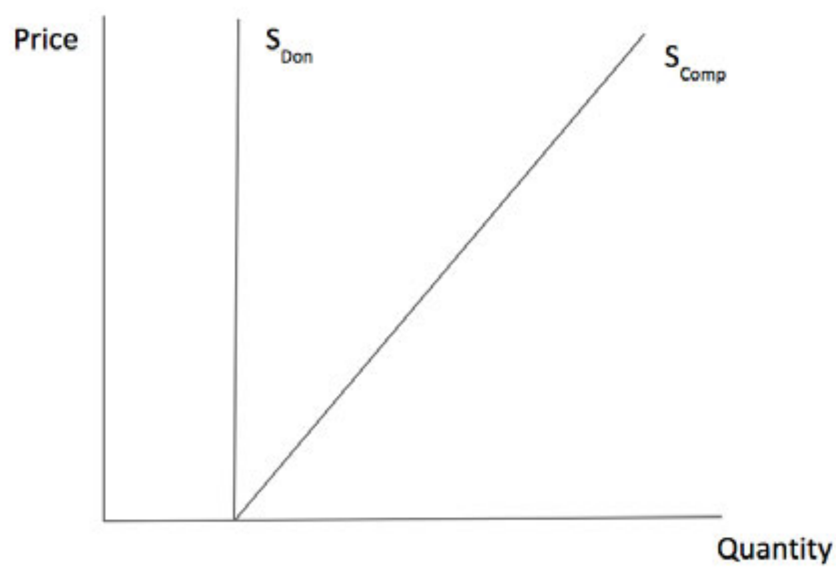
5. Hemostasis and Closure: After vascular and biliary anastamoses are completed, a reperfusion biopsy is performed to restore blood flow to the liver. Perfect hemostasis, or the stoppage of blood-flow, is ensured, drains are placed, and the wound is closed. Ensuring perfect hemostasis will prevent re-explorations and postoperative liver function abnormalities.

Problems with current allocation system

Prior to the National Organ Transplant Act, surgeons could use whatever organ allocation the organ procurement organization that received the organs chose, including allocating organs to parties who were willing to pay the highest price. This, however, resulted in surgeons allocating organs away from Medicare and Medicaid patients, who routinely paid only 50 percent of what private insurers and cash payers paid (Munshower 2000, 16). To provide transplants as part of federal entitlements, Congress needed to either pay more under entitlement programs to encourage allocation of organs toward Medicare and Medicaid patients or altogether alter the organ allocation method to limit physicians' abilities to allocate organs to the patients of their choice. They chose the latter, essentially seizing control of all cadaveric organs and placing federal oversight over allocation of organs as a method of ensuring proportional allocation to Medicare and Medicaid recipients without having to pay a competitive market rate for the procedure (Munshower 2000, 16-20).

Since, under the act, donors cannot be compensated for their organs, a large supply shortage exists, in concurrence with microeconomic theory. Figure 1 below depicts the supply of livers for transplantation from altruistic donors (labeled S_{Don}), as well as the supply of livers that would exist if donors were compensated (labeled S_{Comp}), assuming that no altruistic donors are dissuaded from donating if they are offered compensation (Thorne 2006). It is apparent that the supply of livers is vastly diminished when compensation in return is not offered.

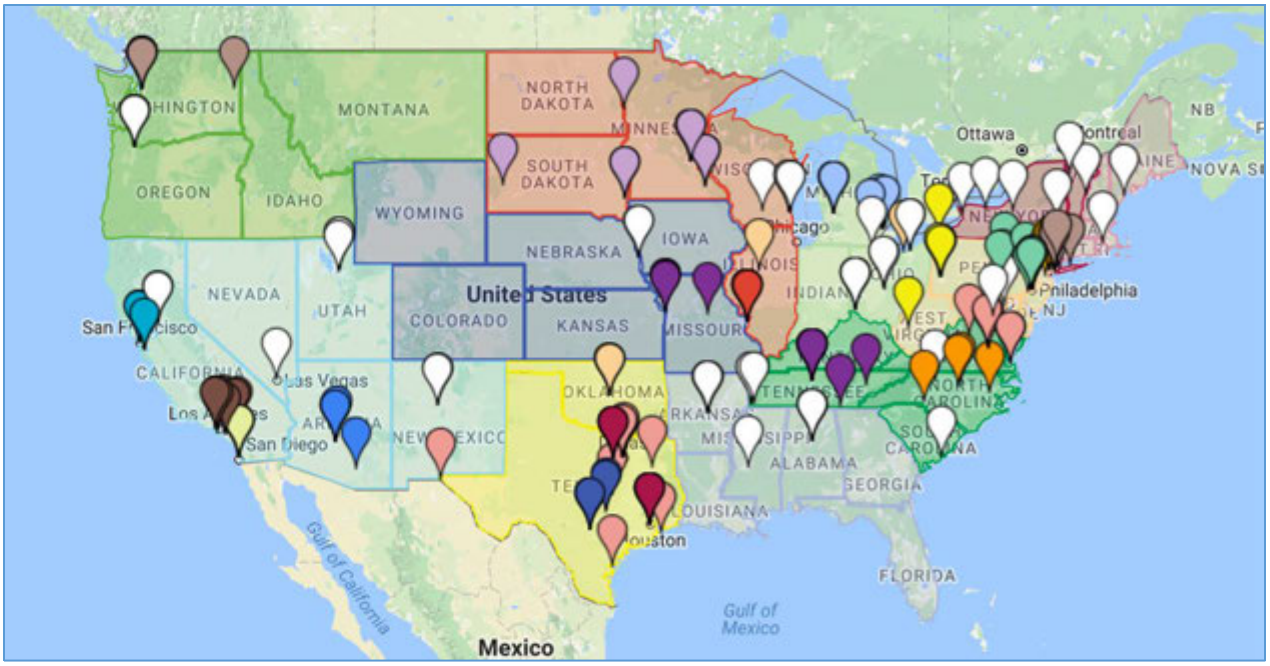
Figure 1. Supply of livers with and without compensation



Source: Thorne 2006

In addition to causing vast organ shortages, the system currently in place has essentially made geographic access a pricing mechanism instead. Consider how livers are currently allocated to patients.When an individual is deemed to be of a health status warranting a transplant, he or she is registered to the waitlist of one of 58 organ procurement organizations, based on which of the 58 corresponding designated service areas (DSAs) he or she resides in (Organ Procurement and Transplantation Network Policies, 112-115). The DSAs are also sorted into regions, which group together several adjacent states. The map below depicts the color-coded regions as well as individual OPOs/DSAs with pins in the contiguous United States.

Figure 2: Map of organ procurement organizations and regions in the 48 contiguous states



Pins represent each of the 58 OPOs, which are surrounded by corresponding DSAs
Color-coded groups of states represent regions (11 total)
Source: Google Maps

Candidates aged 18 or older are assigned one of the following upon registration:

- Adult status 1A
- Calculated MELD score
- Exception MELD score
- Inactive status

Candidates below the age of 18 are assigned one of the following upon registration:

- Pediatric status 1A
- Pediatric status 1B
- Calculated MELD or PELD score
- Exception MELD or PELD score
- Inactive status

Adult status 1A, the most severe assignment, indicates, in the case of candidates aged 18 or older, a patient with a life expectancy without a liver transplant of less than seven days and at least one of five conditions: fulminant liver failure; the patient is anhepatic, or liverless; primary non-function of a transplanted liver within 7 days of transplant; hepatic artery thrombosis (HAT); or acute decompensated Wilson's disease. Among candidates below the age of 18, pediatric status 1A indicates that the candidate suffers from one of four specific ailments: fulminant liver failure, primary non-function of a transplanted liver, HAT, or acute decompensated Wilson's disease. Pediatric status 1B indicates that the candidate suffers from one of three ailments (biopsy-proven hepatoblastoma without evidence of metastatic disease, organic acidemia or urea cycle defect and a MELD or PELD exception score of 30 points for at least 30 days, or chronic liver disease with a calculated MELD or PELD score of greater than 25) (Organ Procurement and Transplantation Network Policies, 99-103).

Apart from those extremely severe cases, most candidates are assigned a MELD or, if the candidate is less than 12 years of age, PELD score. The MELD score is calculated using a formula that takes into account creatinine, bilirubin, and INR levels, while the PELD score is calculated using a formula that takes into account albumin, bilirubin, and INR levels (Organ Procurement and Transplantation Network Policies, 102-103). A higher MELD or PELD score indicates a more severe need for a transplant, with the highest possible score being 40 (Organ Procurement and Transplantation Network Policies, 102).

Should a liver for donation arise, the closest organ procurement organization claims it, filters out all candidates based on a match for blood type, and proceeds to allocate it according to the criteria depicted in Table 1, if the donor of the liver was between the ages of 11-17, Table 2, if the donor of the liver was less than 11 years of age, or Table 3, if the donor of the liver was 18 years of age or older, with a lower classification number corresponding to a higher claim on the organ.

A key point is that, while most candidates register to an organ procurement organization close to their residence, they are theoretically allowed to be tested and subsequently registered to a waitlist in how many ever OPOs they like, wherever they like, as long as the candidate and his transplant surgeon are able to receive the liver from the OPO's transplant center in time to complete the transplantation within the liver's cold ischemic time period (transplant window), which lasts up to 12 hours (Furukawa et al. 1991, 1000-1004).

The consequences of this allocation methodology are easily observed. Patients awaiting a transplant are inclined to register to whichever OPOs they can, especially to the ones that will give them the highest chance of receiving a transplant. A study by three Michigan State University economists found that in states where motorcycle helmet laws were repealed, the number of transplantable organs from donors killed in motor vehicle accidents increased by 20 percent. After these supply shocks occurred, inflows to local transplant waitlists increased by roughly 12 percent (Dickert-Conlin, Elder, & Teltser 2015, 4). Candidates and their physicians observed the increase in the rate of allocation of organs to waitlisted candidates in a certain designated service area, and they subsequently responded by registering on those corresponding waitlists to take advantage of it.

Table 1: Livers from donors aged 11-17

Classification	Candidates that are within the:	And are:
1	OPO's DSA	Pediatric status 1A
2	OPO's region	Pediatric status 1A
3	OPO's DSA	Adult status 1A
4	OPO's region	Adult status 1A
5	OPO's DSA	Pediatric status 1B
6	OPO's region	Pediatric status 1B
7	OPO's DSA or region	Any PELD
8	OPO's DSA	MELD of at least 15 and 12 to 17 years old
9	OPO's DSA	MELD of at least 15 and at least 18 years old
10	OPO's region	MELD of at least 15 and 12 to 17 years old
11	OPO's region	MELD of at least 15 and at least 18 years old
12	OPO's DSA	MELD less than 15 and 12 to 17 years old
13	OPO's DSA	MELD less than 15 and at least 18 years old
14	OPO's region	MELD less than 15 and 12 to 17 years old
15	OPO's region	MELD less than 15 and at least 18 years old
16	Nation	Pediatric status 1A
17	Nation	Adult status 1A
18	Nation	Pediatric status 1B
19	Nation	Any PELD
20	Nation	Any MELD and 12 to 17 years old
21	Nation	Any MELD and at least 18 years old
22	OPO's region	Any PELD, and compatible blood type
23	OPO's DSA	MELD at least 15, 12 to 17 years old, and Compatible blood type
24	OPO's DSA	MELD at least 15, at least 18 years old, and compatible blood type
25	OPO's region	MELD at least 15, 12 to 17 years old, and compatible blood type
26	OPO's region	MELD at least 15, at least 18 years old, and compatible blood type
27	OPO's DSA	MELD less than 15, 12 to 17 years old, and compatible blood type
28	OPO's DSA	MELD less than 15, at least 18 years old, and compatible blood type
29	OPO's region	MELD less than 15, 12 to 17 years old, and compatible blood type
30	OPO's region	MELD less than 15, at least 18 years old, and compatible blood type
31	Nation	0 to 11 years old and compatible blood type
32	Nation	12 to 17 years old and compatible blood type
33	Nation	Any MELD, at least 18 years old, and compatible blood type
34	OPO's DSA	Adult or pediatric status 1A and in need of other method of hepatic support
35	OPO's DSA	Pediatric status 1B and in need of other method of hepatic support
36	OPO's DSA	Any MELD/PELD and in need of other method of hepatic support
37	OPO's region	Adult or pediatric status 1A and in need of other method of hepatic support
38	OPO's region	Pediatric status 1B and in need of other method of hepatic support
39	OPO's region	Any MELD/PELD and in need of other method of hepatic support
40	Nation	Adult or pediatric status 1A and in need of other method of hepatic support
41	Nation	Pediatric status 1B and in need of other method of hepatic support
42	Nation	Any MELD/PELD and in need of other method of hepatic support
43	OPO's DSA	Any MELD/PELD in need of other method of hepatic support, and compatible blood type
44	OPO's region	Any MELD/PELD in need of other method of hepatic support, and compatible blood type
45	Nation	Any MELD/PELD in need of other method of hepatic support, and compatible blood type

Source: OPTN

Table 2: Livers from donors below age of 11

Classification	Candidates that are within the...	And are...
1	OPO's region	Pediatric status 1A
2	Nation	Pediatric status 1A (0-11)
3	OPO's DSA	Adult status 1A
4	OPO's Region	Adult status 1A
5	OPO's Region	Pediatric status 1B
6	OPO's Region	Any PELD
7	OPO's DSA	MELD of at least 15 and 12 to 17 years old
8	OPO's DSA	MELD of at least 15 and at least 18 years old
9	OPO's Region	MELD of at least 15 and at least 12 to 17 years old
10	OPO's Region	MELD of at least 15 and at least 18 years old
11	OPO's DSA	MELD less than 15 and 12 to 17 years old
12	OPO's DSA	MELD less than 15 and at least 18 years old
13	OPO's Region	MELD less than 15 and 12 to 17 years old
14	OPO's Region	MELD less than 15 and at least 18 years old
15	Nation	Status 1A and 12 to 17 years old
16	Nation	Status 1A and at least 18 years old
17	Nation	Status 1B and 0 to 17 years old
18	Nation	Any PELD
19	Nation	Any MELD and 12 to 17 years old
20	Nation	Any MELD and at least 18 years old
21	OPO's Region	Any PELD and compatible blood type
22	OPO's DSA	MELD of at least 15, 12 to 17 years old, and compatible blood type
23	OPO's DSA	MELD of at least 15, at least 18 years old, and compatible blood type
24	OPO's Region	MELD of at least 15, 12 to 17 years old, and compatible blood type
25	OPO's Region	MELD of at least 15, at least 18 years old, and compatible blood type
26	OPO's DSA	MELD less than 15, 12 to 17 years old, and compatible blood type
27	OPO's DSA	MELD less than 15, at least 18 years old, and compatible blood type
28	Region	MELD less than 15, 12 to 17 years old, and compatible blood type
29	Region	MELD less than 15, at least 18 years old, and compatible blood type
30	Nation	Any PELD and compatible blood type
31	Nation	Any MELD, 12 to 17 years old, and compatible blood type
32	Nation	Any MELD, at least 18 years old, and compatible blood type
33	OPO's DSA	Adult or pediatric status 1A and in need of other method of hepatic support
34	OPO's DSA	Pediatric status 1B and in need of other method of hepatic support
35	OPO's DSA	Any MELD/PELD and in need of other method of hepatic support
36	OPO's region	Adult or pediatric status 1A and in need of other method of hepatic support
37	OPO's region	Pediatric status 1B and in need of other method of hepatic support
38	OPO's region	Any MELD/PELD, any age, and in need of other method of hepatic support
39	Nation	Adult or pediatric status 1A and in need of other method of hepatic support
40	Nation	Pediatric status 1B and in need of other method of hepatic support
41	Nation	Any MELD/PELD, any age, and in need of other method of hepatic support
42	OPO's DSA	Any MELD/PELD, any age, in need of other method of hepatic support, and compatible blood type
43	OPO's region	Any MELD/PELD, any age, in need of other method of hepatic support, and compatible blood type
44	Nation	Any MELD/PELD, any age, in need of other method of hepatic support, and compatible blood type

Source: OPTN

Table 3: Livers from donors aged 18+

Classification	Candidates that are within the:	And are:
1	OPO's region	Adult or pediatric status 1A
2	OPO's region	Pediatric status 1B
3	OPO's DSA	MELD/PELD of 40
4	OPO's region	MELD/PELD of 40
5	OPO's DSA	MELD/PELD of 39
6	OPO's region	MELD/PELD of 39
7	OPO's DSA	MELD/PELD of 38
8	OPO's region	MELD/PELD of 38
9	OPO's DSA	MELD/PELD of 37
10	OPO's region	MELD/PELD of 37
11	OPO's DSA	MELD/PELD of 36
12	OPO's region	MELD/PELD of 36
13	OPO's DSA	MELD/PELD of 35
14	OPO's region	MELD/PELD of 35
15	OPO's DSA	MELD/PELD of at least 15
16	OPO's region	MELD/PELD of at least 15
17	Nation	Adult or Pediatric status 1A
18	Nation	Pediatric status 1B
19	Nation	MELD/PELD of at least 15
20	OPO's DSA	MELD/PELD less than 15
21	OPO's region	MELD/PELD less than 15
22	Nation	MELD/PELD less than 15
23	OPO's DSA	MELD/PELD at least 40 and compatible blood type
24	OPO's region	MELD/PELD at least 40 and compatible blood type
25	OPO's DSA	MELD/PELD of 39 and compatible blood type
26	OPO's region	MELD/PELD of 39 and compatible blood type
27	OPO's DSA	MELD/PELD of 38 and compatible blood type
28	OPO's region	MELD/PELD of 38 and compatible blood type
29	OPO's DSA	MELD/PELD of 37 and compatible blood type
30	OPO's region	MELD/PELD of 37 and compatible blood type
31	OPO's DSA	MELD/PELD of 36 and compatible blood type
32	OPO's region	MELD/PELD of 36 and compatible blood type
33	OPO's DSA	MELD/PELD of 35 and compatible blood type
34	OPO's region	MELD/PELD of 35 and compatible blood type
35	OPO's DSA	MELD/PELD of at least 15 and compatible blood type
36	OPO's region	MELD/PELD of at least 15 and compatible blood type
37	Nation	MELD/PELD of at least 15 and compatible blood type
38	OPO's DSA	MELD/PELD less than 15 and compatible blood type
39	OPO's region	MELD/PELD less than 15 and compatible blood type
40	Nation	MELD/PELD less than 15 and compatible blood type
41	OPO's DSA	Adult or pediatric status 1A and in need of other method of hepatic support
42	OPO's DSA	Pediatric status 1B and in need of other method of hepatic support
43	OPO's DSA	Any MELD/PELD and in need of other method of hepatic support
44	OPO's region	Adult or pediatric status 1A and in need of other method of hepatic support
45	OPO's region	Pediatric status 1B and in need of other method of hepatic support
46	OPO's region	Any MELD/PELD and in need of other method of hepatic support
47	Nation	Adult or pediatric status 1A and in need of other method of hepatic support
48	Nation	Pediatric status 1B and in need of other method of hepatic support
49	Nation	Any MELD/PELD and in need of other method of hepatic support
50	OPO's DSA	Any MELD/PELD in need of other method of hepatic support, and a blood type compatible with the donor
51	OPO's region	Any MELD/PELD in need of other method of hepatic support, and blood type compatible with the donor
52	Nation	Any MELD/PELD in need of other method of hepatic support, and blood type compatible with the donor

Source: OPTN

There also exist other systematic differences across OPO regions in the availability of livers for donation. For instance, Region 3, which includes the Deep South, an area plagued by higher rates of obesity, high blood pressure, and diabetes as well as above average rates of fatal car accidents, procured 1,336 of the 7,841 total livers in 2016. Region 9, which includes densely populated New York, only 327 livers were procured in the same year (Bernstein 2017). Certain regions procure organs at a rate vastly disproportionate to their populations, which results in the availability of donated organs differing significantly depending on the OPO region in question. There exist noticeable disparities on the demand side of the equation as well. In 2016, the median MELD score in Indiana was 20 while the median score in the Los Angeles area was 40 (Bernstein 2017). Urban centers have populations with higher rates of hepatitis C and fatty liver disease, and cities such as San Francisco with large Asian and Hispanic populations, who are more prone to liver disease, face disproportionately higher demand and therefore lower access to donated livers (Bernstein 2017).

The only barrier stopping individuals from registering to every one of the 58 regional waitlists is that they cannot reasonably obtain a liver from the other side of the country and undergo the transplantation procedure within 12 hours. However, candidates have various levels of financial resources, and surely the number of waitlists a given candidate is registered to is commensurate with his or her financial ability to travel to far-away designated service areas at a moment's notice.

Consider, as an extreme case, billionaire Steve Jobs's liver transplant in 2009. Jobs was likely on every designated service area's waitlist and, when a liver became available to him in Memphis, Tennessee (a region where the average time spent on the waitlist before receiving a liver was just four months between 2002 and 2007, compared to the national average of over one year) he flew in on his private jet from California in the middle of the night to receive it and undergo the transplant (Hainer 2009).

Furthermore, individuals from outside of the United States are also able to enter waiting lists for transplants in the United States, and this has attracted a large number of wealthy "medical tourists." Between 2013 and 2016, 252 foreigners came to the United States for the sole purpose of receiving cadaveric liver transplants, while another 100 livers were allocated to foreigners staying in the United States as non-residents (Ornstein 2017).

Such measures are not available to the vast majority of individuals on the waitlists, and therefore this allocation system favors the wealthy few who can take such extraordinary measures. Insurance does not cover transportation to the transplant location, while it would cover the cost of paying for an organ if that were possible. As such, the current allocation system in place is actually less equitable than the system it replaced, in which livers could be bought and sold.

Compensation for kidney donors

Considering the numerous pitfalls of the current waiting list and allocation system, a viable alternative could be a free market for organs in which individuals are compensated for donating organs while they are alive (i.e., donating one kidney or a segment of a liver), or promising to donate organs should they die and their organs be salvageable.

Because kidneys are in far more demand than any other organ (81.2 percent of all organ transplant waitlist candidates are waiting for kidneys, compared to 11.9 percent for livers), most research on compensation for organ donors has focused on kidneys (U.S. Department of Health and Human Services, Health Resources & Services Administration).

Compensation for kidney donors has been considered by several researchers. In a qualitative study based on in-depth interviews of living kidney donors in New Zealand, researchers found that most of the 25 participants agreed that the kidney donation process was costly both in terms of time and money and many of them incurred personal costs and experienced financial hardship as a result of their benevolence. Fifteen of the 25 participants favored compensation in return for kidney donation, and nine favored reimbursements for specific costs, while none of the participants were opposed to all forms of compensation (Shaw and Bell 2014, 3205-3207).

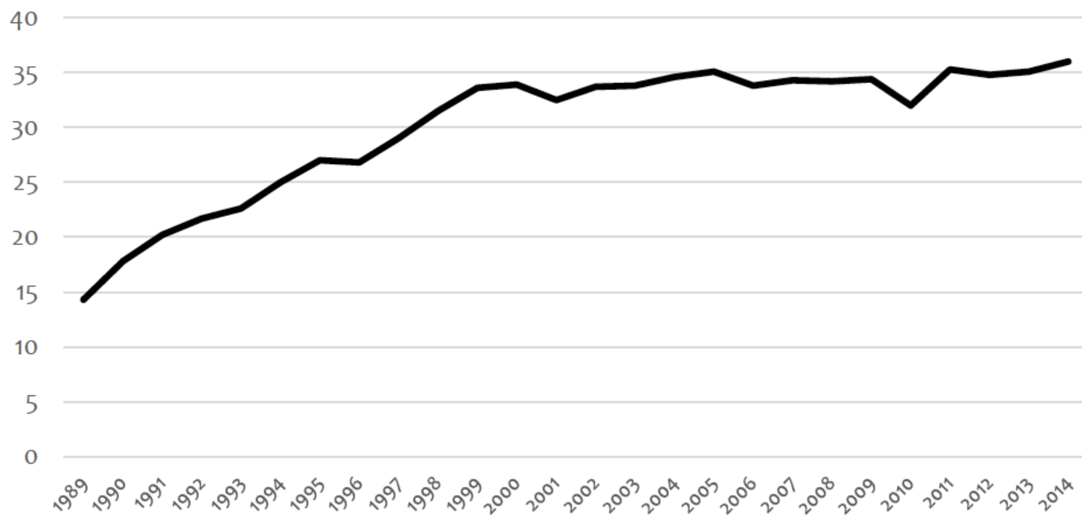
A similar study was conducted among 19 kidney donors in Perth, Western Australia, all of whom were either genetically or emotionally related to the potential recipient. The participants reported having to take time off of work in addition to taking on travel expenses, and many of them encountered financial difficulties as a result of their donations (Cuesta-Briand, Way, & Boudville 2015, 309-310).

One study published by Stanford economists notes that the U.S. government routinely spends tens of billions of dollars per year on kidney dialyses for Medicare and Medicaid recipients, and analyzes the cost-benefit of instead compensating individuals for donating kidneys to those in need. They conclude that, at a price of $45,000 per living kidney and $10,000 per cadaveric kidney, which they surmise would effectively negate the shortage, taxpayers would save about $12 billion per year, and recipients would become far more productive (Held, McCormick, Ojo & Roberts 2015).

In 1989 in Spain, the Organización Nacional de Transplantes (ONT), the national transplant authority, began a program in which organ procurement officials are allowed to offer monetary compensation, generally presented as funeral cost assistance, to families of deceased, potential donors (Beard, Kaserman & Osterkamp 2013, 42-43). As a result, the number of deceased donors increased from around 550 per year in the late 1980s to over 1,300 per year by the mid-2000s. In fact, prior shortages in the country have been eliminated and the waiting list has been reduced substantially. Figure 3 depicts the number of kidney donations per million citizens in Spain since the implementation of the program.

In one study, researchers analyzed data on kidney donations in Spain since the program's inception and found that the nation successfully ameliorated its prior shortage by 1997-1998, just under a decade after the program was implemented (Mixon, Jr. and Upadhyaya 2017, 7-10).

Figure 3: Number of kidney donation per million population in Spain



Source: Organizacion Nacional de Transplantes

Unfortunately, due to lack of transparency and published figures, it is unknown exactly how much Spanish officials offered in compensation. The researchers who investigated the data note that the number of donations in Spain increased by 119 percent, and reference survey evidence reported by Adams et al. in 1999 that suggested that compensating U.S. donors with $1,000, approximately equal to $1,470, would have been sufficient to increase the quantity of cadaveric organs supplied in the U.S. in 1996 by 117 percent. They claim that it follows that, since the increase in predicted donations by Adams et al. and the increase in actual donations in Spain were very close, that the Spanish officials must have been offering deceased donors' families around $1,400 in today's currency in euros (Mixon, Jr. and Upadhyaya 2017, 12-13).

Drawing such a conclusion is a bit of a stretch, especially considering that, as the researchers acknowledge, Spain had relatively low dialysis populations compared to the U.S., indicating that the demand must have been far lower, and such a relationship may not have held constant when taking into account the sheer number of kidneys demanded in the United States. It is important to note, however, that the $1,470 for all cadaveric organs from a deceased individual suggested by Adams et al. is nowhere close to the $10,000 for a cadaveric kidney alone suggested by Held et al. Clearly the only way to get a true sense of the price of a kidney would be to make the trading of them legal and allow the free market price to equilibrate based on supply and demand.

Differences between livers and kidneys

There exist numerous differences between both the transplantation process for kidneys and livers and the nature of the organs themselves. These differences must be accounted for when comparing the potential compensation schemes for donors of each organ, especially in relation to each other.

Every individual has two kidneys (only one of which is necessary for survival), but only one liver. However, just a segment of a liver can regenerate to full size. Therefore, in general, one of each organ can typically be procured from a live donor while two of each can be procured from a deceased donor (U.S. Department of Health and Human Services, Health Resources & Services Administration).

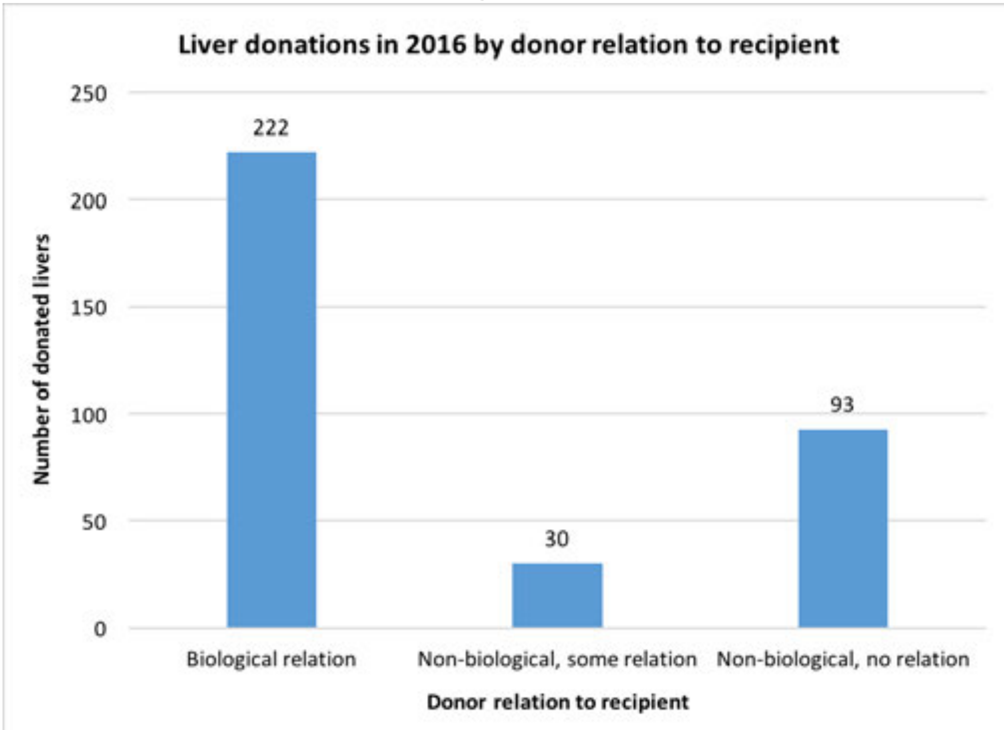
When considering compensation of donors, the risk that the donors take on when undergoing a transplantation has to be taken into account. Kidney donors must typically stay in the hospital for 3-7 days, while liver donors must stay for approximately one week (Steiner 2016; Llado and Figueras 2017, 73-75). Since both types of transplantation involve invasive surgery, all of the associated risks exist for both. While the majority of complications following surgery are not severe, they may cause longer hospitalization. For donations of both organs, lost wages from time spent in the hospital must obviously be considered when contemplating compensation for donors, and liver donors, on average, are hospitalized slightly longer than kidney donors.

Risks associated with donating either organ include hernia, organ impairments or failure resulting in the need for transplantation (or dialysis in the case of kidneys), and death. Risks associated solely with kidney donation include high blood pressure and urination of large amounts of protein (Steiner 2016). On the other hand, risks associated solely with donating a liver include wound infections, abdominal bleeding, bile leakage, narrowing of the bile duct, and intestinal problems including blockages and tears (Butt, et al. 2012). So, there are significantly more possible complications associated with donating a liver than with donating a kidney, implying that other things being equal, liver donors would require higher compensation.

Compensating liver donors to reduce shortage

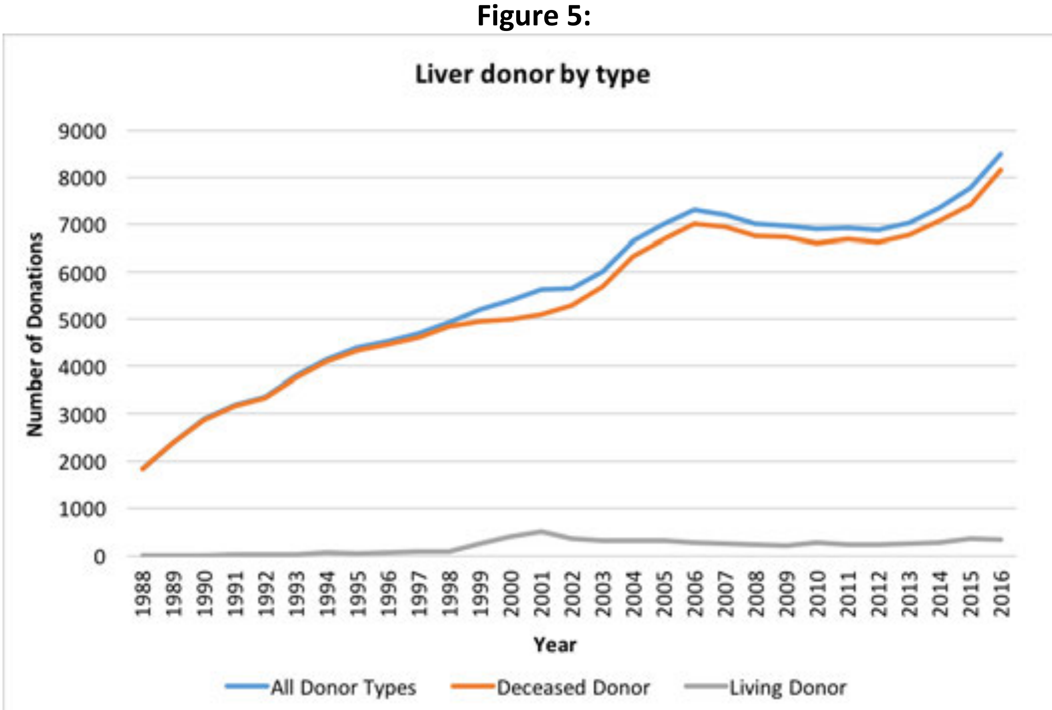
To increase the supply of livers, compensation schemes to encourage both more living and cadaveric donations would have to be created. Figure 4 depicts the number of liver donations by live persons made in 2016 by relationship between donor and recipient. Even though any given individual in need of a liver would have far more compatible matches for donation among the general population with no relation to them, biological or otherwise, such donations comprise the minority of living liver donations (UNOS). In a way, the 252 donors who gave a liver to a relative, biological or otherwise, received compensation in the form of the satisfaction of their loved one’s improvement in health, if not survival.

Figure 4:



Source: UNOS

Figure 5:

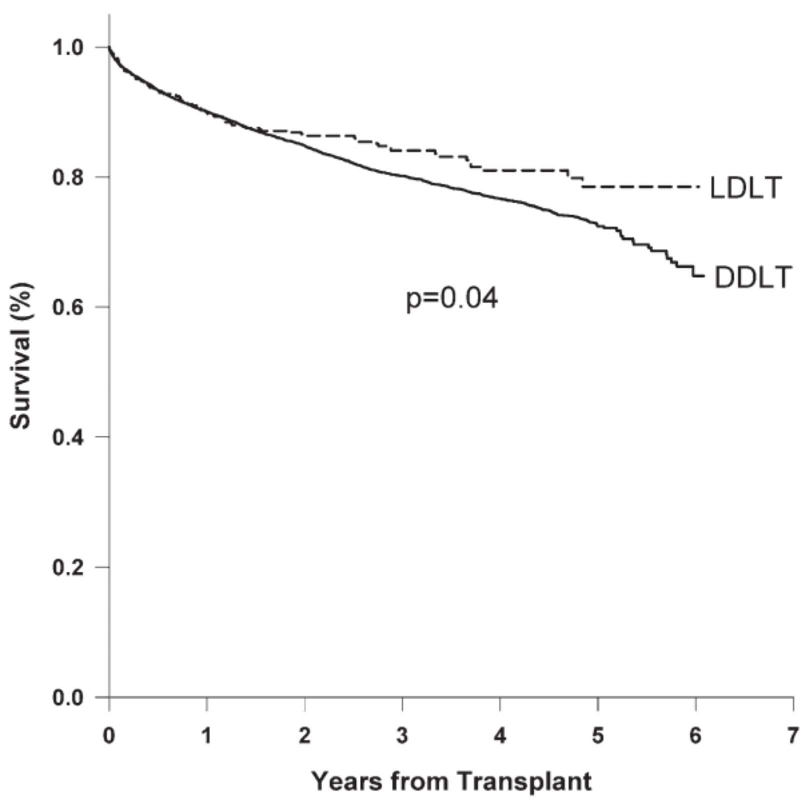


Source: OPTN

Figure 5 above depicts U.S. liver donations each year from 1988 to 2016. While the total number of transplantations has increased significantly, the number by living donors has plateaued and, as a proportion of all donations, has decreased. In 2016, there were only 345 living liver donations, comprising 4.06 percent of all donations (U.S. Department of Health and Human Services, Health Resources & Services Administration).

As Figure 6 below shows, the post-operative survival rates of recipients receiving living donor liver transplants are higher than those receiving cadaveric transplants (Hoehn, et al. 2014, 1349-1353). Unfortunately for recipients, people are less inclined to donate an organ while they are still alive under the current system. Because of the sudden nature of liver supply from deceased donors (since the donor's death usually cannot be predicted ahead of time with exactness), cadaveric livers can realistically only be sold to recipients able to receive the liver and undergo the transplant operation within the twelve-hour transplant window. A living donor's liver, on the other hand, can be sold to anyone in the country, and therefore there would be far more demand for a living donor's liver. Because of these factors, one would expect the price of a liver from a living donor to be higher than that of a cadaveric liver.

Figure 6: Survival rates of Living Donor (LDLT) and Deceased Donor Liver Transplants (DDLT)



Source: Hoehn, et al. 2014

The increased waiting times in the hospital for donors, coupled with increased risk of complications and higher mortality rates among recipients of cadaveric livers, imply that the difference in prices of a living liver compared to prices of a cadaveric liver would be larger than the difference in prices of a living kidney compared to the prices of a cadaveric kidney. So, for example, if Held, McCormick, Ojo, and Roberts are correct, and a cadaveric kidney would cost $10,000 while a living kidney would cost $45,000, or a premium of $35,000 for a living kidney, then the premium for a living liver over a cadaveric liver would likely be greater than $40,000.

The first criterion that must be considered when considering transplants is compatibility between donors and recipients. Among livers, the two primary criteria for compatibility, and often the only considered criteria, are blood type and size (Starzl, et al. 1982). Because of differences in blood antigens and antibodies, all recipients can receive livers from donors with either blood type O or the same blood type as themselves, except for recipients with blood type AB, who can receive livers from all blood types (Gordon, et al. 1987). Table 1 below provides a breakdown of the percentage of the population that recipients can receive livers from depending on their blood types. With regard to size, because the liver must sit in the hepatic fossa without getting dislodged or twisting out of position, recipients typically receive livers from donors either the same size or larger than they are (Llado and Figueras 2004, 73-75).

Table 4: Compatibility of blood types in transplantation

Blood Type:	Proportion of general population:	Can receive liver from:
O	45%	45%
A	40%	85%
B	11%	56%
AB	4%	100%

Source: Gordon, et al. 1987

Based on blood type alone, since a liver donation from a donor with AB blood type can be utilized by only 4 percent of the population while a liver from a donor with blood type O can be used by 100 percent of the population, there will be differences in the quantity demanded of livers based on blood type. Whether or not these differences result in differences in prices depends on whether or not the quantity supplied varies from the quantity demanded. For instance, if donors and potential recipients are representative of the general population, which with large enough numbers they likely will be, then the 4 percent of donors that have type AB blood can donate to the 4 percent of recipients that have type AB blood. However, if for whatever reason the proportion of blood types among donors is not equal to the proportion of blood types among recipients, type O blood will be worth relatively more than other blood types, since every recipient can receive a liver from a donor of type O blood. So, for instance, if there are not enough type B blood liver donors, type B blood potential recipients will have to compete with type O blood potential recipients for type O livers, thus driving up the price of type O blood livers relative to other types.

In reality, due to the ethnic make-ups of various blood types as well as the disproportionate levels of donation among different ethnicities, potential recipients of type B blood require disproportionately more livers, while type B blood donors donate at disproportionately lower rates. As a result, recipients of type B blood consume a significant portion of the available type O and, on occasion, even type A livers (Ottmann 2017). If healthy individuals of type B blood are compensated enough (likely at higher levels than their other blood-type counterparts), the disparity between supply and demand for type B blood livers could be eliminated. The positive effects of such a practice is twofold: recipients of type B blood livers will receive better matches at higher rates, while the demand for type O blood, and to a lesser extent, type A blood livers, would decline.

Furthermore, since livers from larger donors can be transplanted into smaller recipients, but not vice versa, livers from larger donors would be in higher demand and, as a result, the price would be higher.

In addition to blood type and patient size, the following factors are taken into consideration in some cases when matching a potential liver donor to a recipient and may affect the outcome of the transplantation: Age, Gender, Ethnicity, CMV (Cytomegalovirus) infection, HBV (Hepatitis B infection), HCV (Hepatitis C infection), Blood group A2 and HLA antigen matching (Reddy, Varghese, Venkataraman, & Rela 2013, 604-608). These criteria are only considered in certain cases, and their impacts on the success of transplantation and survival among recipients are not entirely agreed upon, and therefore their impacts on prices would be subject to further research and future data on health outcomes. While their impact on pricing cannot be known now due to this fact, it is important to acknowledge their potential impact on pricing and demand.

Overall, however, it is important to note that, under current practices, the likelihood that two random people will be a match for livers is higher than the likelihood that they'll be a match for kidneys, since less matching tests are administered on average, and, therefore, the supply for livers would be relatively higher and would serve to reduce the relative price of livers to kidneys. However, it is possible that, if the supply of donated livers were to increase substantially, recipients might in turn demand livers that they are a relatively better match for, and as a result, those less important tests that might incrementally increase survival rates would likely become far more common.

It is also important to consider the methodology of creating a market for livers. While, for living liver donors, it is up to the donor to choose to donate, and would then be up to the market-making body in place to find a recipient, things are not quite as easy for cadaveric liver transplants.

One possible system that could be implemented for cadaveric liver transplants could be one in which people under the age of 40 (ideal candidates for donation should they die) (Reddy, et al.

2013, 604) could be offered a relatively small sum to undergo blood tests and have their height and weight measured, since this information is of utmost importance in matching donors with recipients. This information could then be cross-referenced with the current waitlist, and based on the demand for a liver of those characteristics, the market-making body could quote a price for the liver. If the potential donor is satisfied with the potential price, he or she can agree to it and sign a contract stipulating that, should they at some point be rendered in a brain-dead state, they agree to having his or her liver, and possibly other organs, to be harvested and donated, and in return his or her estate is compensated by the agreed upon amount.

Such a system would solve two problems. Firstly, it would allow the market-making body to have a better sense of how many donated livers it could expect to collect. It could do this by collecting data on the probability that a given person under the age of 40 with the characteristics of the individuals in questions will be in a state in which his or her organs can be harvested, and can purchase enough future-liver-donor contracts accordingly. For instance, if the organization finds that individuals of a particular height and weight and a particular blood type have a 1 percent likelihood of ending up in a brain-dead state before the age of 40, the organization can assume that, by purchasing futures on 100 such individuals, it can expect to collect on one such liver, and therefore fulfill demand for one such liver. If people are willing to plan for such outcomes, it is possible that such a system could act as a form a life insurance for potential donors.

The second problem that this system solves is with regard to securing cadaveric organs in the first place. For people who do not declare that they would like to be organ donors, and end up in a brain-dead state, healthcare providers ask the family for permission to harvest the organs. In such cases, procurement rates of organs are only around 50 percent, and more often than not families have a difficult time deciding because they have no knowledge of their family members' wishes with regard to organ donation (Roggenkamp, Aldridge, Guy & Rocheleau 2007, 369-372). By offering every individual a small sum just to get the requisite tests, and then allowing them to decide whether or not they want to sign up for organ donation, such cases of indecision could be avoided.

Forms of compensation

A common objection by critics of compensation for organ donation is that it can be used to exploit people and that mentally unhealthy or unstable individuals might sell their organs to fund drug use, gambling addiction, or other vices. While this is certainly a possibility, it is one that can be rectified by offering compensation in forms other than cash. Compensation can be offered in the form of tax credits, tuition, or a variety of other methods to dissuade criminals and other wrongdoers from taking advantage of such a system.

The possibility of tax credits or tax relief specifically has been explored in detail with regard to kidneys already. In "The Kindest (Tax) Cut: A Federal Tax Credit for Organ Donations," Satel and Viard propose that a $50,000 federal tax credit for a kidney donation from a living individual and a $5,000 federal tax credit for the donation of kidneys, intestines, the pancreas, the liver, and lungs would serve to both reduce the shortage of organs available for donation while saving the government billions of dollars a year (Satel and Viard 2017, 1623-1632). They note that a tax credit, as opposed to a deduction, would be fully refundable and ensure that the tax savings that donors recognize would be independent of their tax bracket. They also propose an additional credit that would serve to reimburse donors for the costs of resulting follow-up medical care for any complications within three years of the transplant. Moreover, they note that a potential donor could be required to wait at least six months before the donation procedure takes place to ensure that he or she is not acting impulsively, and that the tax credit itself could be deployed over the course of several years, both of which serve to further prevent the system from being misused by financially unstable or desperate individuals. Such an incentive program could be administered for liver donors as well, and would likely serve to both increase liver donations while decreasing the burden of recipients of Medicare and Medicaid on the government, since, without a functioning liver, they require billions of dollars in medical care each year.

Conclusions

The National Organ Transplant Act of 1984 was implemented with the primary purpose of establishing equality among donated organ allocation. Unfortunately, however, it has resulted in a vast shortage of organs available to those in dire need, causing tens of thousands of deaths every year. Moreover, it has not eliminated the inequity in organ allocation, since wealthier individuals are still capable of multi-listing on several organ transplant waitlists at a time and receiving donations at a higher rate than their impoverished counterparts.

Implementing a commercial market for organs, especially for livers, as discussed in this paper, would benefit virtually all of those in need by creating a real incentive for individuals to donate segments of their livers, or agree ahead of time to donate in the possible case of their brain death. Donors take on significant risk, as well as commit significant amounts of money to donations when considering travel, hospital, and forgone wage expenses, so compensating them in turn is one way to reasonably achieve adequate levels of procurement. Doing so would allow those on waitlists to receive the organs they so desperately need without putting undue stress on those that decide to donate.

References

"Abdominal incisions in general surgery: a review." *National Center for Biotechnology Information.* Department of Surgery, College of Medicine University College Hospital Ibadan, Nigeria. Web. Jun. 2018.

"About the OPTN." *Organ Procurement and Transplantation Network.* U.S. Department of Health and Human Services – Health Resources and Servcies Administration. Web. Jul. 2017.

Adair, Anya and Wigmore, Stephen J. "Paid organ donation: the case against." *The Annals of The Royal College of Surgeons of England.* pp. 191-192. 2011. Web. Aug. 2017.

Azzam, Ayman. "History and Evolution of Liver Transplantation." *Liver Transplantation - Basic Issues.* pp. 1-4. 2012. Web. Aug. 2017.

Beard, T.R., Kaserman, D.L., and Osterkamp, R. *The Global Organ Shortage: Economic Causes, Human Consequences, Policy Responses.* Stanford University Press. pp. 43-45. Aug. 2017.

Bernstein, Lenny. "Who deserves a liver? Officials try to make organ transplants fairer." *The Washington Post.* 2017. Web. Sep. 2017.

Blumstein, James F. "Government's Role in Organ Transplantation Policy." *Journal of Health Politics, Policy, and Law.* pp. 27-28. 1989. Web. Aug. 2017.

Butt, Zeeshan, et al. "Quality of life, Risk Assessment, and Safety Research in Liver Transplantation: New Frontiers in Health Services and Outcomes Research." *HHS Author Manuscripts.* pp. 241-247. 2012. Web. Aug. 2017.

Cuesta-Briand, Beatriz, Wray, Natalie, and Boudville, Neil. "The Cost of Donation: Potential Living Kidney Donors' Perspectives." *Health & Social Work.* pp. 307-315. 2015. Web. Aug. 2017.

Dickert-Conlin, Stacy, Elder, Todd, and Teltser, Keith. "Allocating Scarce Organs: How a Change in Supply Affects Transplant Waiting Lists." *Montana State University.* pp. Working paper, 2015. pp. 1-51. Web. Aug. 2017. https://msu.edu/~dickertc/Allocating%20Scarce%20Organs_Nov-12-2015.pdf

Furukawa, Hiroyuki et al. "Effect of Cold Ischemia Time on Early Outcome of Human Hepatic Allografts Preserved with UW Solution." *HHS Author Manuscripts.* pp. 1000-1004. 1991. Web. Aug. 2017

Ghahramani, N. "Living Organ Donation: An Ethical Evolution or Evolution of Ethics. *International Journal of Organ Transplantation Medicine.* pp. 57-62. 2010. Web. Aug. 2017.

Gordon, R. D., et al. “Experience With Primary Liver Transplantation Across ABO Blood Groups.” *HHS Author Manuscripts.* pp. 4575-4579. 1987. Web. Aug. 2017.

Hainer, Ray. “Did Steve Jobs’ money buy him a faster liver transplant?” *CNN Health.* 24 June. 2009. Web. Aug. 2017.

Held, P. J., McCormick F., Ojo, A., and Roberts, J. P. “A Cost-Benefit Analysis of Government Compensation of Kidney Donors.” *American Journal of Transplantation.* pp. 877-885. 2015. Web. Aug. 2017.

Hoehn, Richard S., et al. “Comparing living donor and deceased donor liver transplantation: A matched national analysis from 2007 to 2012.” *Liver Transplantation.* pp. 1349-1353. 2014. Web. Aug. 2017.

Lladó, L. and Figueras, J. “Techniques of orthotopic liver transplantation.” *The Official Journal of the International Hepato-Pancreato-Biliary Association.* pp. 69-75. 2004. Web. Aug. 2017.

Mercer, Lily. “Improving the rates of organ donation for transplantation.” *Art & Science.* pp. 35-40. 2013. Web. Aug. 2017.

Mixon Jr., Franklin G. and Upadhyaya, Kamal P. “Donor Compensation and the Elimination of the Organ Shortage in Spain: Evidence from Break Point Analysis.” *Journal of Statistical and Econometric Methods.* pp. 9-15. 2017. Web. Aug. 2017.

Munshower, Eric J. “The Minimization of Lost Income in Procurement and Allocation Markets for Human Transplant Organs.” PhD. Purdue University, 2000. pp. 7-18. Web. Aug. 2017.

Ornstein, Charles. “Some U.S. Hospitals Don’t Put Americans First for Liver Transplants.” *ProPublica,* n.p. 2017. Web. Nov. 2017.

Ottmann, Shane. Personal Interview. 25 October 2017.

Reddy, Mettu S., Varghese, Joy, Venkataraman, Jayanthi, and Rela, Mohamed. “Matching donor to recipient in liver transplantation: Relevance in clinical practice.” *World Journal of Hepatology.* pp. 604-608. 2013. Web. Aug. 2017.

Roggenkemp, Susan D. et al. “Exploring the Relationship of Hospital and Market Characteristics and Organ Donation in U.S. Hospitals.” *Journal of Healthcare Management.* pp. 369-372. 2007. Web. Aug. 2017.

Satel, Salley and Vinard, Alan D. “The Kindest (Tax) Cut: A Federal Tax Credit for Organ Donations.” *Tax Notes.* pp. 1623-1632. 2017. Web. Sep. 2017.

Shaw, Rhonda M. and Bell, Laura J.M. "'Because you can't live on love': living kidney donors' perspectives on compensation and payment for organ donation." *Health Expectations.* pp. 3201-3212. 2014. Web. Aug. 2017.

Sheehy, Ellen et al. "Estimating the Number of Potential Organ Donors in the United States." *The New England Journal of Medicine.* pp. 667-674. 2003. Web. Aug. 2017.

Starzl, Thomas E. et al. "Evolution of Liver Transplantation." *HHS Author Manuscripts,* n.p. 1982. Web. Aug. 2017.

"Stats and Facts." *DCI Donor Services Tissue Bank.* Web. Aug. 2017.

Steiner, Robert W. "The Risks of Living Kidney Donation." *The New England Journal of Medicine.* np. 2016. Web. Aug. 2017.

Sullivan, Walter. "Buying of Kidneys of Poor Attacked." *The New York Times.* np. 1983. Web. Aug. 2017.

Thorne, Emanuel. "The Economics of Organ Transplantation." *Department of Economics, Brooklyn College of the City University of New York,* p. 1344. 2006. Web. Feb. 2018.

Weimer, David L. "Public and Private Regulation of Organ Transplantation: Liver Allocation and the Final Rule." *Journal of Health Politics, Policy and Law.* pp. 18-49. 2007. Web. Aug. 2017.