The Market of Kidney Transplantation in the United States

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**Introduction**

In the United States, there are many medical conditions, which require and/or benefit from various organ transplantations. The characteristics of the markets for each type of organ are very diverse ranging in size, time constraints, geographical range, government regulations, and incentives. While patients with particularly complex medical issues might require multiple organ transplants, the scope of our investigation is to focus on one of the more prevalent organ transplants: the kidney.

We will discuss the current market conditions regarding kidney transplantations. This will include incentives that affect the behavior of producers and consumers, characteristics of consumers/patients and how they affect the transplantation market, the inputs used in production of the transplant (along with the incentives and outcomes of these input markets), and the government role in the market for kidney transplantation. From our research and analysis of the kidney transplantation market, we will provide an entrepreneurial recommendation to address a gap that exists in this line of transplantation service: shortage.

Lastly before we begin, we would like to define a few key terms that will be used throughout our investigation. The output is the kidney transplant surgery itself. The inputs are the kidney, and the capital inputs and labor inputs necessary to complete the surgery. The producers are the providers who perform the transplant service and the donor who supplies the “transplantable kidney.” Consumers are the patients who demand a kidney transplant. Lastly, the suppliers of these inputs are the medical facilities with a kidney transplant service line and the donor of the transplantable kidney.

For clarification purposes, all human beings are a biological producer of a kidney. Regarding the market for organ transplantation, some human beings become an economic producer of a “transplantable kidney” when they register to donate. Lastly, the donor becomes a supplier of the transplantable kidney when the decision is made to go through with the kidney donation and surgery, which leads to the final output of a transplanted kidney.

**Current Incentives Affecting the Behavior of Producers and Consumers**

The kidney transplantation market has a unique mix of producers and consumers. The consumers are understandably those who need a kidney and are on the kidney transplant waiting list. The producers are a combination of both kidney donors, who supply the transplantable kidney, and healthcare providers, who perform the transplantation surgery.

Discussing the current incentives that affect the behavior of consumers is difficult due to the complex nature of needing a kidney. These patients need a kidney for survival and/or to increase the quality of their life. This drives their behavior of securing an optimal spot on the kidney transplant waiting list. Specifically patients are incentivized to meet the eligibility requirements of refraining from active substance abuse (alcohol or drugs) and attending all dialysis appointments (Barnes and Jewish Hospital). In addition, if patients are not already
covered through Medicare (ESRD patients are covered by Medicare) or other insurance plans, they are motivated to obtain coverage. However, as it will be discussed later, there are many other clinical factors that affect the outcome of obtaining a kidney and subsequently having the transplant surgery.

The first level of kidney transplantation producer is the kidney donor because they produce the transplantable kidney. These donors have minimal tangible incentives in registering as a donor: the process where the capital input of a kidney and the labor of registering as a donor produces the transplantable kidney. Specifically, there is no monetary reward or wide-scale public recognition. The main incentive for living donors revolves around the goodwill of saving a life. Furthermore, many donors are helping their own friend or family member who is in need of a kidney. Thus, the personal relationship to the patient often serves as a strong incentive to donate the kidney. Another type of kidney donation comes from those who have chosen to be organ donors after they expire. The incentive for these donors also has to do with wanting to save lives as the part of their lasting legacy. The incentive to save a life drives the behavior of donating a kidney either during life or signing up to do so upon death.

The second level of kidney transplantation producers is the providers. The current incentives that affect the behavior of providers are a combination of goodwill, clinical interest, and possible financial returns. Any provider involved in the care of a transplant patient will be in the industry partially for the goodwill of helping save lives and/or increase the quality of the patient’s life. Another incentive lies in the personal area of interest for the provider as organ transplantation might be one of the areas that they are particularly intrigued by, from a medical and research standpoint. Physician reimbursement varies widely across states and insurance plans; however, the reimbursement could be a possible incentive to produce the service and stay in the industry (Showstack et al., 1999). In addition, the process of kidney transplantation involves a lot more than the surgery itself: the process includes preliminary testing, transplantation surgery, and postoperative recovery services. The United Network for Organ Sharing (UNOS) outlines costs involved in the process, including insurance, testing, surgery, organ procurement, follow-up care, fees for providers (surgeons, physicians, radiologist, anesthesiologist, and periodic testing), anti-rejection and other drugs, and rehabilitation. Thus, the providers have financial incentive to perform the surgery, as they will receive reimbursement for the costs involved in the transplantation process. It is important to note that these potential financial incentives for providers to perform/promote kidney transplantations also exist for other substitute treatments (such as hemodialysis). Thus, providers have financial incentives to promote/perform kidney transplantations and their substitutes-- simply the exact level of financial compensation is variable. The main incentive, then, for providers to promote/perform the surgery over these substitutes is due to their desire to save and improve the quality of patients’ lives along with their ethical constraint to do what is best for the patient.
Characteristics of Consumers/Patients: Their Needs, Preferences, and Constraints Affecting the Market

The characteristics of consumers/patients are especially important in the market of kidney transplants. Whereas in a traditional market, there is a generic consumer and a generic producer, kidney transplantation requires a specific producer to a consumer. When we say generic, we refer to the fact that a given product can be used by any consumer, regardless of intrinsic properties of that consumer. Take, for example, the market for a pen. Any pen producer can make a pen to be used by any consumer, regardless of race, height, weight, or previous experiences. In the market for kidney transplants, on the other hand, there is a high degree of specificity that needs to be present between a product and consumer. In this case, the product is the kidney transplant, which is contingent upon the harvested kidney as an initial input, and the consumer is the patient in need of the transplant.

The first characteristic that must be considered when determining whether a kidney is specific for a patient is genotypic matching. The reason genotypic matching is important is because kidney rejection is a serious problem for improperly matched organs. Kidney rejection can lead to significant morbidity, reoperation, and death (Kasiske 1998). To prevent kidney rejection, both the donor and consumer must have a matching genotype, which takes into account, blood type, immune system compatibility, and several genetic factors. The first available kidney in the market, therefore, may not be useful for the first consumer in line for a kidney. This specificity of kidney to patient, in turn, reduces the supply of kidneys in an already scarce market to further create a shortage.

Other factors that must be taken into account in addition to genotypic matching include those used by UNOS. UNOS determines kidney allocation based on measurements of the following factors: life years from transplant, dialysis time, and donor profile index (Kasiske 1998). This makes the supply and demand relationship even more complex. Not only does the genotypic matching factor into who gets a kidney, but also how long he/she has needed one, consequences of not receiving one, how long he/she would live after receiving the kidney, and urgency of need. Once again, this means that the first person that demands a kidney is not necessarily the first person that receives one. This further constrains supply augmenting the shortage.

The fact that there is a third party that dictates who deserves a kidney or not is also another characteristic that prevents this from being a completely free market. In a traditional free market, there is the supplier and the consumer. In this case, there is the supplier, the consumer, and the third party. The supplier consists of two parties: the kidney donor and the providers that perform the transplantation surgery. The consumer is the patient, and the third party is UNOS, because they determine who is eligible for a kidney and who has priority. Since UNOS determines eligibility, an increase in the supply of kidneys does not necessarily mean a better chance for an individual to receive one. The supply and demand of kidneys-- and by extension
the ultimate output of a transplantation surgery--therefore, do not affect each other as directly as they would in other markets.

Lastly kidney transplantation is a substitute for hemodialysis whereby patients often prefer to improve their quality of life by having the transplant. Hemodialysis requires patients to come in many times a week to filter their blood, consequently interrupting their way of life. Kidney transplantation requires follow-up appointments, but not nearly as often as undergoing hemodialysis, which makes the patients much more independent and gives them a higher quality of life. For some though, there is the extra constraint of time--not every patient can stay on hemodialysis indefinitely and will instead require a transplantation (personal communication with Transplant Nurse Manager Amber Thomas at VCUHS, 2014). Thus, hemodialysis is not a perfect substitute for kidney transplantation. If a kidney is not available in time, the patient will expire: on average 21 per day (HRSA, 2015). This time constraint augments the issue of the shortage in the market.

The Inputs Used in the Production of Kidney Transplantation

There are two main inputs used in the production of kidney transplants. The first input is the kidney itself, and the second are the capital and labor inputs necessary for the transplantation surgery. The kidney is the most essential input for the transplantation surgery and is supplied by the donor.-The biological production side of the kidney relates to when the donor has created the kidney out of his/her own physiological needs.-The donor, having already been a producer of a transplantable kidney by registering to donate, becomes a supplier of the transplantable kidney as an input once the decision to transplant the kidney takes place. Thus, there are no additional incentives for a producer of a transplantable kidney to supply it as an input, there are only the aforementioned incentives (discussed in the producer characteristics/incentives section) associated with registering to donate the kidney, e.g. goodwill.

The second input is the medical facility that supplies the capital and supportive resources necessary for the producers (providers) to complete the transplant surgery. The first step, after the preliminary testing in transplantation surgery, is harvesting and transporting the organ from the donor. Of note, the facility that harvests the kidney is not always the one where the transplantation surgery takes place. The characteristics and incentives for the medical facilities that house the harvesting and transplanting of the organ are the same.

The characteristics of the medical facilities are that they need to have the necessary capital, staff, and supportive resources needed to complete the surgery and conduct pre- and post-surgery care (e.g. an operating room, hemodialysis machines, outpatient lab, and recovery units). Often this takes the form of hospitals having an entire transplant department with very specialized equipment and highly trained and skilled staff.

Having a transplant department requires a lot of initial capital. Medical facilities are incentivized to have one by the financial benefits as well as the need to meet their community health assessments. Depending on the reimbursement levels, a facility might lose money on the
actual harvesting and transplantation service particularly regarding issues with Diagnostic Related Groups and above-average Length of Stays. These facilities house the pre-and-post transplant treatments, which add additional revenue for the facility. Specifically, patients require immunosuppressants pre-and-post transplant as well as require frequent lab work and visits with various staff. Thus, the financial incentives for a medical facility to have a transplant department depend on a case-to-case basis, as the surgery side may or may not produce a financial benefit, but pre-and-post transplant work is often a source of revenue. There also are not that many non-financial incentives for a facility to have this department, as often it’s just a department that their community needs (personal communication with Transplant Nurse Manager at VCUHS).

Other associated labor inputs supplied by the medical facility are the additional personnel associated with the transplant including the transplant nurses, transplant coordinator, anesthesiologist, social worker, dietician, pathologist, and pharmacist (personal communication and rounds with Transplant Nurse Manager at VCUHS). Additional inputs include the organ transportation system between hospitals.

The effects of incentives for suppliers on the market of kidney transplants is mixed. The lack of overwhelming incentives, financial or otherwise, do not affect the input market regarding medical facilities: there is not a shortage of medical facilities to perform kidney transplants (HRSA, 2015). However, as mentioned before, there is a lack of incentives for people to produce a “transplantable kidney” by signing up to donate, and there are no additional incentives for someone to supply that kidney once the decision to go through with the surgery has been made. Because of the limited incentives, few people take the steps of going beyond being a biological producer of a kidney for their own physiological needs. This means few individuals become a producer of a transplantable kidney by registering to donate, and even fewer become a supplier of the transplantable kidney once the decision to go through with the surgery has been made. This all, along with the aforementioned clinical constraints, creates the shortage of transplantable kidneys and kidney transplants in the market.

Ultimately, this shortage has created a market where there is a continuously increasing gap between the supply and demand for organ transplants because of the shortage of transplantable kidneys, which yields a shortage of kidney transplant surgeries. Over the last ten years there has been a substantial increase in consumers (patients) that need a kidney and a very small increase in the amount of organ donors (Becker & Elias, 2014). Figure 1 illustrates this problem of the ever-increasing shortage across all organ transplant markets. This increase in the quantity demanded for kidney transplants is attributable to the ever increasing U.S. population, as well as better outcomes in successful kidney transplantation, making patients feel more confident about undergoing the surgery. The small increase in the amount of kidney donations could be due to the increasing population, but it has not kept pace with the demand due to things

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1 Some registered donors will end up being unable to donate their transplantable kidney, e.g. because they acquire HIV/AIDS. Additionally many are registered as donors, but are not actively going through the testing necessary to be matched with a patient because they have registered to be a deceased donor.
like safer cars and work environments, and the overall increase in the quality of medicine and longer life expectancies.

Figure 1. The Need Continues to Grow (HRSA, 2015)

According to UNOS, in 1990 almost 17,000 people in the United States were waiting to receive a kidney transplant. By 2006, this number had grown to about 65,000 people on the kidney transplant waiting list (Becker & Elias, 2007). As of 2010, the official kidney waiting list, maintained by the Organ Procurement and Transplantation Network (OPTN), had reached approximately 84,100 patients (Beard et al., 2012). In part, this increase in the number of people waiting to receive a kidney can be attributed to technological progress over the years that has reduced the cost and poor outcomes associated with organ transplants. However, a much larger part of this increase in the number of people waiting for a kidney transplant can be attributed to longer wait times to receive the organ due to the scarcity of organs and inefficiencies in organ procurement (Becker & Elias, 2007). In other words, the slight increase in kidney transplants since the 1990s has not met the growth in demand for the organ. As a result of the growing demand for kidneys, many observers have questioned whether the current system for organ procurement and subsequent kidney transplant is capable of meeting the relatively inelastic demand for kidneys.

The Governmental Role in the Kidney Transplantation Market

About 18 patients die each day in the United States as a direct result of the shortage of kidneys available for transplantation (Beard et al., 2012). The government’s role in the market for kidney transplantation is a complicated, if not controversial one, and the excess demand for
kidneys is a critical policy issue. Under federal U.S. law, there are strict legal limits on the market for kidneys and all other organs. That is, under the National Organ Transplant Act of 1984 (NOTA), it is illegal for organs to be bought and sold on the market (Kessler & Roth, 2014). If a market for organs was legal in the United States, the equilibrium price would be determined by supply and demand and would rise or fall relative to the change in supply or demand of each organ. Furthermore, the legal procurement of organs for transplantation is largely a function of UNOS, which operates the aforementioned OPTN that was created by Congress under NOTA (Beard et al., 2012). Regional Organ Procurement Organizations (OPOs) have monopoly rights to collect organs within their regions and OPOs and large transplant centers in the U.S. have some autonomy and control over admission to the transplant waiting list at their facilities (Beard et al., 2012). OPOs have the responsibility to increase the number of registered donors in their service areas and to coordinate the donation process when donors become available. According to the federal law, OPOs must be members of the OPTN and must be certified as well as abide by the Centers for Medicare and Medicaid Services (CMS) regulation (U.S. Department of Health & Human Services, 2015).

The behavior of the government plays a major role in the effect on the market for kidney transplants. Federal legislation in the U.S. prohibits the use of monetary payments as a means to increase living or deceased organ donation and this undoubtedly affects the supply of kidneys in the market. Additionally, the Uniform Anatomical Gift Act requires consent for deceased donation, either by the individual registered as the organ donor or by the deceased’s next of kin (Kessler & Roth, 2014). Organ donation registration usually takes place at the state level at a state’s Department of Motor Vehicles (DMV) whereby individuals “opt-in” (or check “yes”) if they would like to join the registry for organ donation. Policy change in the U.S. has resulted in states such as Illinois, California, and New York switching from opt-in registry to a “mandated choice” frame in which individuals check yes if they would like to be added to the registry or check no if they would not (Kessler & Roth, 2014). In the opt-in framework, individuals leave the organ donation field blank, thereby choosing not to register as a donor. The assumption is that individuals will be more willing to join a registry when asked under a mandated choice option than when asked under the current opt-in framework. However, according to the National Donor Designation Report Card, only 43% of Americans are registered organ donors, despite the relative ease of becoming one.

The ultimate consequence of the government’s behavior (e.g. its policies) is that it augments the shortage within the market and also generates a black market for organ-- and specifically kidney-- transplantation. Mandating that individuals opt-in to being a donor creates a shortage of potential donors because of the cost of registering: while the cost is minimal in terms of time, some people forget or are unwilling to make a special trip to the DMV just to re-register as a donor. Potential donors also possess imperfect information, which may deter them from actually registering as donor. Specifically many individuals do not know about the shortage within the market or the process of donating and harvesting organs. There is also the perception/urban legend that if you are a registered donor and you are in an emergency that
requires life-saving care, providers will let you die in order for your organs to be used for other people. This fear is not helped by the government’s heavy emphasis on consent and the steps that one needs to take in order to register as a donor. Ultimately, while not necessarily contributing to the fear, the government’s actions and lack of adequate public education do not alleviate the information imperfection. Consequently, too few individuals produce a transplantable kidney by registering to donate, which creates a shortage of transplantable kidneys and a shortage of kidney transplants. As a result, the government’s behavior creates a black market as desperate consumers seek other means by which to overcome this transplantable kidney shortage.

**An Entrepreneurial Solution**

As discussed earlier the market of kidney transplantation within the United States is characterized by a shortage. This shortage is not a result of a lack of provider services to perform the kidney transplant itself, but rather due to a lack of transplantable kidneys. This shortage of transplantable kidneys—yielding a shortage of the kidney transplants that consumers demand—has been explained as being due to government regulation, the difficulty of matching from a clinical standpoint, and a lack of living and deceased donors.

With such a constrained supply and demand whose growth continues to outpace the growth in supply, we would advise our entrepreneurial friend to get into the up-and-coming market for artificially grown or created kidneys. Currently scientists are working towards creating artificial tissues and organs in two ways: one by manually growing them within a laboratory (Gallagher, 2013), or two by printing them with three-dimensional (3D) printers (Bullis, 2014). There has also been work done to create a wearable artificial kidney (WAK) (Ronco, 2008). Of the three methods, all have had some success to-date in creating clinically viable substitutes to a donated kidney: scientists at MIT have engineered kidneys for rats (Gallagher), while researchers at Huazhong University of Science and Technology and Harvard have printed living human tissue using a 3D printer (Gidalevitz, 2013; Bullis, 2014). Lastly WAKs have been around for years, but the issue has always been to make them smaller, lighter, and more independent—but with “the advent of nanotechnology and miniaturization,” the viability of WAKs is increasing (Ronco, 2008).

The market for 3D printing as a whole is skyrocketing (Rooney, 2013)—even with the market leader, 3D Systems Corp. taking a dip in earnings in 2014, the market stands at $10.8 billion (Jakab, 2014). When you couple that market with the intense market for organs, we would advise that our friend focus his/her efforts on using 3D printing to create artificial kidneys. Growing them in a laboratory is a more manual process with a higher cost of labor and slower rate of production than the potential speed that 3D printing offers—although 3D printing might have higher capital input costs. As of today there is not a cell therapy or device that repairs damaged kidney tissue (Wake Forest, 2015). Since damaged tissue cannot currently be repaired, there are two options: they can print cells/tissues with the characteristics of kidney cells on an artificial renal device, thereby creating a “mini-kidney”—a structure built to “boost the limited
amount of function left in diseased kidneys,”—or they can try to print an entire kidney itself (Wake Forest, 2015).

To make a patient with End Stage Renal Disease (ESRD) independent of hemodialysis, their kidney function need only be restored to ten to fifteen percent (Gallagher, 2013). Thus, our friend need not try to print an entire kidney, but only these “mini-kidneys” that restore the function of already damaged ones. By focusing on developing mini-kidneys rather than an entire kidney, our entrepreneurial friend could have the capacity to expand into other areas of the 3D printing of human cells, tissues, and organs. The only reason we would advise them to print an entire kidney would be if certain patients needed an entire kidney and/or if market research yielded that physicians and consumers principally wanted an entire kidney with greater functionality rather than a restorative mini-kidney.

Overall entering into the market of printing kidneys, with the potential to enter into other areas of printing human cells, tissues, and organs would be very wise entrepreneurially. The quantity demanded of kidney transplants and by extension transplantable kidneys—or their substitutes—continues to increase, but there is also demand for engineering other parts of the human body ranging from livers, bladders, lungs, blood vessels, and more (Fountain, 2012). Continuing to create these engineered human structures through the use of 3D printing should be more efficient than growing them in a laboratory due to the continual increase in 3D printing innovations and the growth in the overall 3D printing market, as well as the lower cost of labor inputs.

**Conclusion**

The market for kidney transplants is characterized by a shortage, which is attributable to a lack of donors due to government regulations and inadequate incentives: financial or otherwise. With the current market structure the growth in demand continues to outpace the minimal growth in supply for a variety of demographic and clinical reasons. In order for this market to reach equilibrium, efforts must be made to reduce the shortage of transplantable kidneys, which causes a shortage in the supply of kidney transplants. Methods to do so include governmental policy changes at the federal and state levels; however, most notably this shortage could be reduced by investing in the up-and-coming ways of developing artificial kidneys or kidney-substitutes.

To a friend with adequate venture-capital means, we would recommend that they look into these various methods of increasing the supply, with the greatest emphasis being to focus on the 3D printing of “mini-kidneys” that restore the function of already damaged ones: eliminating the requirement for an entirely new kidney altogether. The final ramifications of these newfound technologies on all organ transplants are not entirely known. However methods of production, like 3D printing and the engineering of various tissues and structures, will reduce the shortages present in the supplies within the markets for various transplant surgeries. This will allow more patients to receive the clinical treatment that they need, and potentially eliminate the demand for traditional organ transplants received from donors entirely.
Works Cited


