

Implementing Innovations in US Transplantation System

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Abstract

Can *private jets* help save lives? Yes. Can *short videos* nudge next-of-kin (NOK) to donate more? Also, yes. How has an outsider to the transplantation system, with no previous knowledge or expertise in (any aspect of) healthcare, managed to make a difference? Is imagination really more important than knowledge? In this invited article, I will briefly describe two innovations - OrganJet and Nudge Videos - that I have implemented in the US Transplantation System that have extended the lives of many.

Keywords: Organ Transplantation, OrganJet, Nudge Videos, Equity, Market Design

1 The Importance of Being Virtuous

Let me open with quotes about *virtue* from Benjamin Franklin and Soren Kierkegaard:

Wisdom is knowing what to do. Virtue is actually doing it.

It is wretched to have an abundance of intentions and a poverty of action, to be rich in truths and poor in virtues.

There is abundant and growing literature on Organ Transplantation in our research community - see (Ata et al. 2018) and (Akan 2024) for reviews on deceased donor transplantation operations and policies, the focus of this article - while there are increasing calls for action by the medical profession, especially the transplantation community, and the broader society - see (NASEM 2017) and (NASEM 2022) for a background on the US Transplantation system as well as the top priorities and recommendations for improvements - representing the patients and their families, to increase

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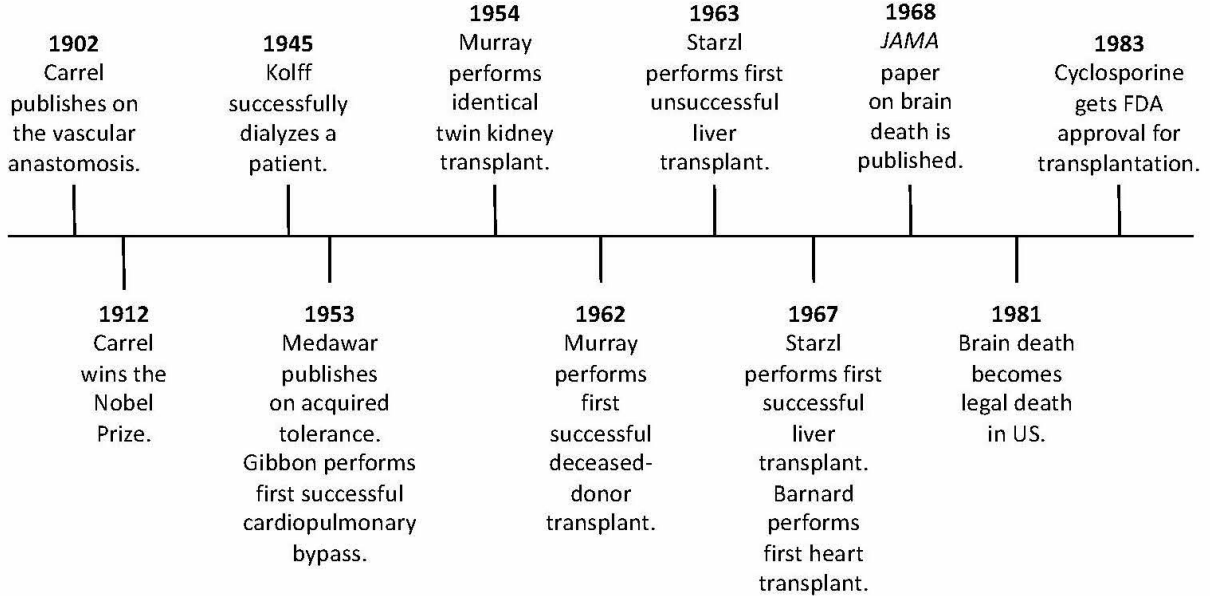


Figure 1: Milestones in Transplantation (Mezrich 2019).

access and improve equity in deceased donor organ transplantation. Mezrich (2019) provides an accessible account, from the perspective of a Transplant Surgeon, of the history of organ transplantation (Figure 1 summarizes the key milestones in transplantation from a medical perspective) as well as the grueling daily work that makes the miraculous lifesaving treatment possible.

In this invited article, I will briefly describe two innovations that I have conceived and implemented, as an outsider to the system: OrganJet (Ata et al. 2016) and Nudge Videos (Kush and Tayur 2022). The former deals with geographic inequity that is particularly severe in the US, and the second addresses an even more fundamental problem that is not limited just to the US but is also prevalent in many countries around the world: the shortage of organ supply. While Organ Transplantation is indeed a serious topic, I agree with Voltaire in believing that:

Solemnity is a disease.

I hope the playfulness (Tayur 2017) of my writing does not mask the seriousness of the issues, nor detract from the two innovative initiatives that have extended many human lives.

“Hi, I am a **single father of 3 with kidney failure**. I am currently doing dialysis waiting for a kidney. I am currently listed at St. Joseph's Hospital in Orange, California. I was told that the waiting time was **10 years for a type O blood** kidney in Southern California. A friend told me about this and I would like any additional information you could provide. Thank you so much for starting this wonderful service.”

Marc

Age: 49 - Blood type: O - Orange, CA – 10 years wait time

Figure 2: Sample email from a transplant candidate on the wait list.

2 If Steve Jobs (and Laurene Powell) can do it...

It is difficult to open this section better than simply quoting Roth (2012) who wrote this on his *Market Design* blog (on October 24th, 2012), less than 10 days after winning his Nobel Prize:

Deceased donor organs in the United States are allocated through regional (not national) waiting lists, which leads to some dramatic differences in waiting times in different parts of the country. Individual candidates for transplantation can register as patients in different regions, if they are healthy and wealthy enough to move around. (e.g. Steve Jobs received a liver in Memphis, although I recall he worked at a company located in California...) He had access to good transportation opportunities.

CMU professor Sridhar Tayur, who will be speaking at Stanford GSB at noon today, has an entrepreneurial project, OrganJet, intended to give that kind of access to transportation to people for whom it has previously been an insuperable obstacle. Here's an article¹ about his operation: Can Private Jets for the Poor Save Health Care Dollars?

Next, excerpting from Walter Isaacson's biography of Steve Jobs (Isaacson 2011):

Powell became the troller of the organ-donation websites, checking in every night to see how many were on the wait lists, what their MELD scores were, and how long they had been on. “You can do the math, which I did, and it would have been way past June before he got a liver in California, and the doctors felt that his liver would give out in about April,” she recalled. So she started asking questions and discovered that it was permissible to be on the list in two different states at the same time, which is something

¹<http://www.bio-itworld.com/2012/10/19/can-private-jets-for-poor-save-health-care-dollars.html>

that about 3% of potential recipients do. Such multiple listing is not discouraged by policy, even though critics say it favors the rich, but it is difficult. There were two major requirements: The potential recipient had to be able to get to the chosen hospital within eight hours, which Jobs could do thanks to his plane, and the doctors from that hospital had to evaluate the patient in person before adding him or her to the list.

I founded OrganJet² in 2011 to democratize Steve Jobs (Battilana and Weber 2013), and almost immediately started to receive emails as in Figure 2. Organjet provides two services: (1) Patient Information Service (PIS) that provides information on where to multiple list (through a self-service website, see Figure 3) and (2) Patient Transportation Service (PTS), that provides on-demand transportation options to get there, on short notice, after the candidate receives a notification that an organ is available. There is also a self-service website for PTS that provides distance and time information for various origin-destination pairs (see Figure 4 for some sample flight paths). Most transplant centers, as part of the evaluation process, require proof of the ability to reach there swiftly, day or night, and so OrganJet also provides that proof (although, the patient, at a later time can take a commercial flight if available, as some have done).

How to let patients know about OrganJet? In 2012, I decided on a multi-pronged approach: (1) have a booth at the American Transplant Congress (ATC) meeting in Boston; (2) give talks at academic institutions (UCLA, Stanford, Harvard) that also have a large transplant program affiliated to their medical school, and (3) alert media through creation of a video³ by CMU. In 2013, we did a press release when our first patient obtained her transplant⁴. The transplant community is quite small and very well connected to each other, and so by the end of 2013 I believe that OrganJet was well known within the transplant community.

While OrganJet was received favorably in general, especially by *fly-in* transplant centers that would gain new patients from out of town, it had some detractors from *fly-out* centers, notably from a prestigious transplant center in NYC. I met the head of transplant surgery to understand the issue: Why, I wondered, would he not want patients to get transplants elsewhere when they are simply going to die waiting? It turns out that his worry was that relatively wealthier (and healthier) patients with better private insurance would disproportionately multiple list, leaving his center with lower paying (by CMS) patients that are also more difficult to do surgery on (higher

²In 2012, I also created GuardianWings that helps subsidize those patients who cannot afford to multiple list.

³<https://www.youtube.com/watch?v=O6Z6k6RF434>

⁴<https://www.prnewswire.com/news-releases/organjet-customer-receives-kidney-transplant-years-faster-due-to-smart-multiple-listing-218674781.html>

Body Mass Index (BMI), for example), and will lead to worse post-transplant outcomes. Indeed, while informing patients about multiple listing is legally mandated, a survey of about 100 patients indicated that a large percentage (over 95%) were completely unaware of it! When I dug deeper with the transplant coordinators (in NYC and Boston), they told me, sheepishly, that they have mentioned it in their presentations, but it is buried in a deluge of information to the patients. So, they were legally safe, but I could see that they were ethically conflicted, but their transplant chiefs had made it clear to them not to encourage multiple listing. Over the next two years, I called out this issue at every presentation I made, and in the case of the NYC center, I threatened⁵ to go to the *New York Times* (since columnist Nicholas Kristof had previously contacted us to learn more about OrganJet). I believe, by the end of 2014, many of the patients contacting OrganJet were actually recommended to do so by their primary transplant centers, including those from NYC.

Beyond the issue above, because the reimbursement for transplantation, whether through private insurance or via CMS, is a *bundled payment*, payable upon completion of the transplantation, and not *fee-for-service* (FFS) based on individual steps (such as initial medical evaluation or periodic checkups while on the wait list), a transplant center does not recoup these expenses if their patient gets transplanted elsewhere. This is a major reason why centers that have short waiting times do not want to share organs. Other reasons include the beliefs that (a) that organ donations will decrease if the organs are not used locally but are being shipped elsewhere and (b) the other regions are not working as effectively as they could to increase donations.

A *New England Journal of Medicine* article (Ubel 2014) clearly summarized the situation:

Since the 1990s, experts have documented dramatic geographic disparities in access to life-saving transplantable organs. These disparities exist because the transplant-allocation system gives priority to local patients, and the supply of transplantable organs does not vary in proportion to the population of patients needing transplants.

The transplant community is considering rule revisions that would reduce these disparities by ensuring that organs are shared more widely throughout the country. But these revisions are mired in political deadlock.

The larger barrier appears to be political: Some small transplant programs might well go out of business, because when scarce organs became available, larger programs with

⁵After the meeting, I was going down in the elevator with the head of transplant coordinators. She said: In my 28 years here, I have never seen anyone talk to him like that. I have never seen him be afraid. Thank you. What I had said to him in that meeting: I am giving you one last opportunity to do the right thing on your own...

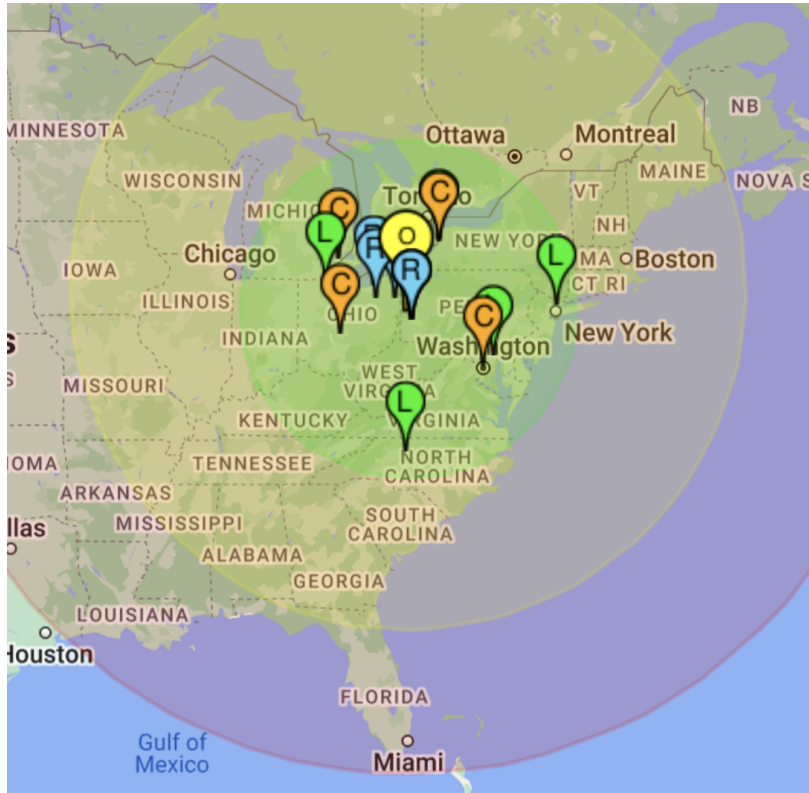


Figure 3: Example of Patient Information Service for a Kidney transplant: Zipcode of home of candidate is 15143 (Origin, O). Closest Regular (R) transplant centers, closest Low-wait (L) transplant centers and closest Children (C) transplant centers are provided in the search. Concentric circles of different colours mark flight times, on a light jet, of one, two and three hours, respectively.

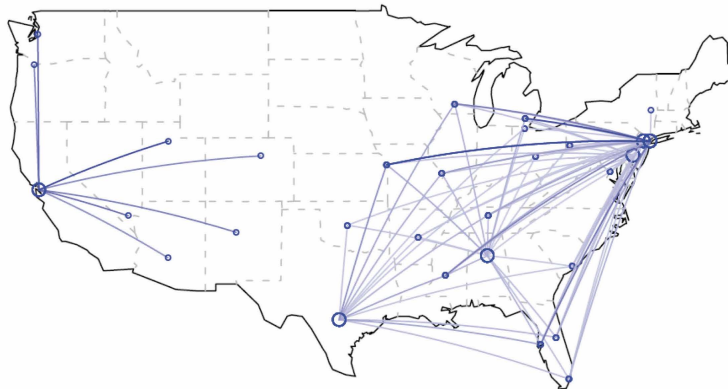


Figure 4: OrganJet: Sample flight paths due to multiple-listing. Large circle represents fly-out locations and small circle denotes fly-in transplantation centers.

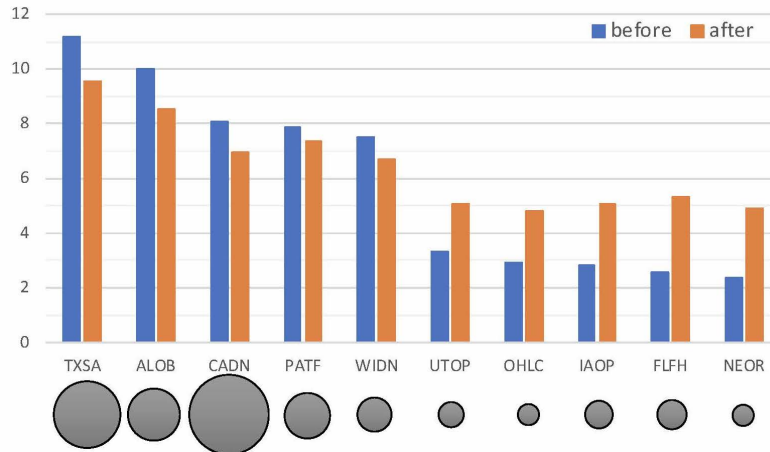


Figure 5: Predicted changes in wait times, for Type O patients, due to multiple listing: Highest five wait time donor service areas and shortest five wait time donor service areas are shown. The circles represent the size of the wait lists at each of the different centers. See Ata et al. (2016) for details.

longer lists of sicker patients would often receive organs ahead of them.

An alternative to mobilizing the transplants is mobilizing the recipients. For example, a start-up company called OrganJet hopes to make long-distance listing more affordable and feasible. There’s reason to think that transporting patients to distant centers would not face the same kind of political resistance that has stood in the way of broader organ sharing to date. If patients, rather than organs, did the traveling, smaller transplant programs would not lose business. Patients living near transplant programs with short waiting times would see their waiting times increase, while those listing themselves at distant centers would see theirs decrease. Disparities in waiting times would consequently be reduced.

Indeed, this is what we have shown in (Ata et al. 2016), where we model the US transplant system as a network of overcrowded queues with abandonment and incorporate patients’ self-optimizing multiple listing behavior via a selfish routing game (see Appendix A). As expected, the longest wait times came down - *even for people who did not travel from a high wait region to a low wait region!* - while there is an increase (but still lower than the long waits) in the short wait time regions (Figure 5).

Interestingly, in reality, there is a higher supply of organs in the low wait areas, because previously they were not harvested if they were deemed of average quality as they would not have

been used. Thus, multiple listing has increased the total number of transplants while reducing the disparity in wait times, benefiting the least advantaged: This is what Rawls would call *the difference principle!* (Sandel 2009) In 2015, I had a wonderful opportunity to meet Amartya Sen, renowned economist and philosopher, and he immediately grasped it, and was very pleased that an abstract philosophical idea of his mentor had been so creatively operationalized in a life and death context by OrganJet. Indeed, the imaginativeness and creativity of OrganJet has been recognized broadly (Cronin and Loewenstein 2018).

The next step in scaling the use of OrganJet was to involve insurance companies. In 2014, a HBS student group project (as part of Regina Herzlinger's class) analyzed the savings possible in dialysis (that costs the insurance companies about \$120,000 a year) for kidney patients if they could be transplanted earlier due to multiple listing. Indeed, it was not difficult to see that the costs due to multiple listing (including the upfront commercial travel for evaluation) would be statistically lower if a sufficient fraction of the patients could get off dialysis a year earlier. I presented these findings to many insurance companies. This is typically a four step process across the C-Suite: (1) Chief Medical Officer signs-off ensuring medical safety; (2) Chief Actuarial Officer approval, after their in-house analytics team redoes the cost-benefit analysis based on their own data; (3) Chief Product Officer approval, whose team identifies how best to insert this innovation into their plans, and market to their corporate customers, many of whom are self-insured companies; and (4) Chief Operating Officer approval, whose team collaboratively creates the process flow map with OrganJet (see Figure 6) and trains their customer service employees. Several self-insured employers have now made multiple listing an employee benefit, administered through their insurance partner.

Where do the jets come from? In the US, there are over 18,000 private jets whose utilization are lower than what their owners would ideally like. OrganJet has created a network of supply of jets around the country, directly working with such owners and through existing brokers who have been managing geographically local sub-networks. This is one of our competitive advantages. We have been reliably able to obtain multiple options for point-to-point travel in many cases in short notice, thus providing patients (and their employers, if it is part of the benefit package) with competitive options, on demand. Operationally, we suggest our patients let us know when they are getting close to the top of the list of the transplant - when they are so alerted from the transplant center - as that gives us ample time to increase the jet options (and so find a lower price).

Here is an email (from the husband of a liver patient, who lives in Boston but was transplanted in Mayo Clinic in Rochester, MN, about two and half hour flight time on a Learjet 45):

A Self-Insured Employer's Benefits System Administered by an Insurance Company

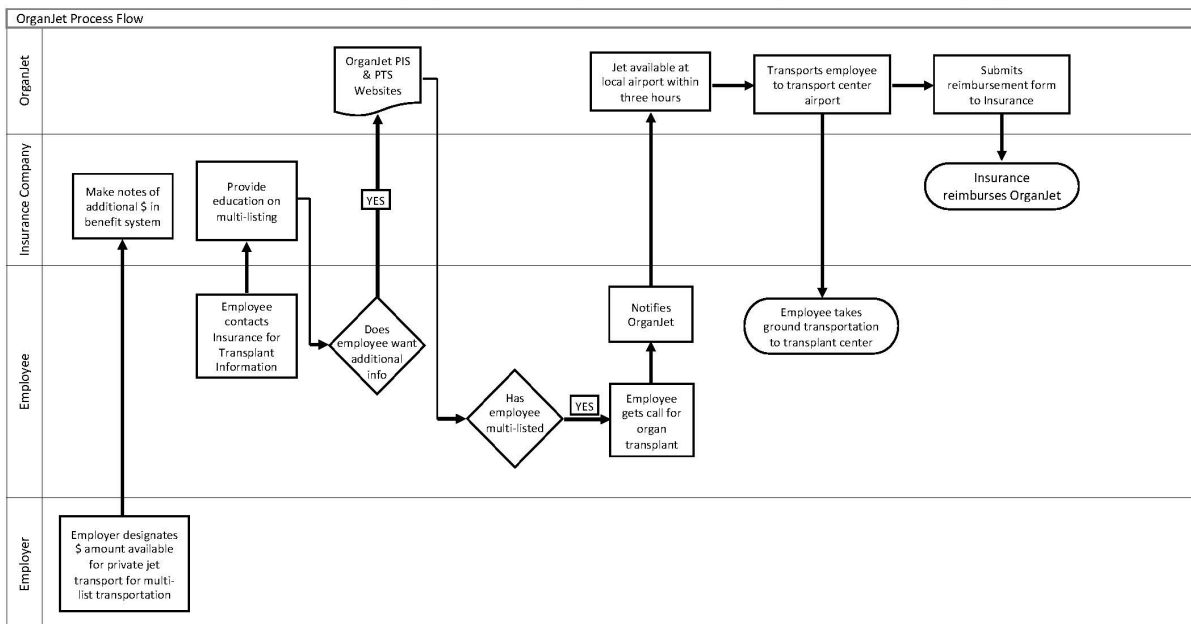


Figure 6: Process for an employee at a self-insured company to multiple list with OrganJet, administered through an insurance company.

We made the trip today on a flight that you arranged for us and all went well. Everyone involved was thoroughly professional, yet friendly, from start to finish. And, we would have been very unlikely to be able to do this trip without your help. Your service made a big, positive difference for us. Thanks again.

Over the past decade, our jet partners have arranged a couple of trips a week on average (we do not track patients who took commercial flights, and know of their transplants only if they contact us). In all cases that we know of, the wait time reduction for our kidney transplant customers comfortably exceeded one year. Half of our liver transplant patients would likely not be alive today (based on their MELD scores and assuming typical evolution of the disease), if not for the multiple listing. While the majority of the patients are for kidney (about 75%) and liver transplants (about 20%), there have been occasional cases for lung, heart and pancreas transplants as well.

In 2024, there are rule changes (Papalexopoulos et al. 2023) that have been approved (for lung) or are being considered (for heart) that allows for a broader sharing using a *Continuous Distribution*⁶ allocation policy where distance between donor and transplant hospital is considered along with other attributes (such as medical urgency and post-transplant outcome); it is too early to tell what the impact will be on the disparity in wait times.

3 A Rabbi, a Priest, and an Imam walk into a conference...

The significant shortage of organs is truly the bottleneck in the transplant system, not only in the US but also in many other countries around the world. In the US, it is difficult to separate organ donation attitudes from religion and other cultural factors (Youngner et al. 1996). The conference mentioned in the title of this section was the Association of Multicultural Affairs in Transplantation (AMAT) Annual Conference, where (in 2016) I was an invited plenary speaker. This conference was an important venue to interact with the OPO (Organ Procurement Organization) decision makers and laid the foundation for future collaborations.

The US, like many other countries, has an *Opt-in* system for becoming a donor, that is, a person has to give consent (at the DMV, for example) and is not, by default, an organ donor; this is called First Person Consent (FPC). For some time now, FPC rates have been flat, not withstanding

⁶Continuous distribution will eventually replace the current classification-based approach, which draws hard boundaries between types of candidates (for example, blood type compatible vs. identical; inside vs. outside a circle based on distance), with a composite score that simultaneously takes into account donor and candidate attributes. This points-based framework intends to create a more equitable and transparent allocation system. <https://optn.transplant.hrsa.gov/policies-bylaws/a-closer-look/continuous-distribution/>

several attempts to move the needle, with nearly two-thirds of the deceased *not* having provided consent. For these situations, a consent from their Next-of-Kin (NOK) is needed; this is called Second Person Consent (SPC), which has been hovering below 50%.

How, then, to increase consent by NOK? Discussions with several donor coordinators (DC) at Organ Procurement Organizations (OPOs) - who do the *asking* - indicated that they were open to innovations that would help their jobs. My idea here was to create *Nudge Videos* that DCs could use if the NOKs were on the fence, for a variety of reasons, including (a) they need to discuss it with other family members that are not present (b) unclear on their religious beliefs (for example among Catholics, especially from Latin American countries) and (c) distrust with the healthcare system due to racial history (especially African-Americans).

The videos emphasize the positives of being a donor and discourage negative feelings about donation based on religion or minority membership, using interviewees who are demographically representative of NOK of that region. The videos also discuss the idea that an open casket is fine, that one wants the (deceased) loved one to be a hero and that many people can be helped.

Figure 7 shows a real-world situation in which a Nudge Video⁷ was used successfully. This was what I presented at the 2016 Annual AMAT Conference that was attended by not only religious leaders across different faiths, but also by community leaders of various minority groups and DCs of various OPOs. Earlier that summer, in June 2016, I was invited to the (Obama) White House Organ Summit (as was Al Roth), where the Nudge Video initiative was highlighted in a *White House Fact Sheet* as a top innovation. As an outsider to the world of OPOs, these occasions provided both legitimacy as well as a target-rich opportunity to refine the idea and scale its use.

In 2020, I was the keynote speaker at the Annual Association of Organ Procurement Organization (AOPO) meeting, where I presented results from a field experiment in Nevada⁸ (Kush and Tayur 2022) and other OPOs (such as Georgia and New Jersey). Most of the 58 OPOs were in attendance. The DCs in several OPOs have now been trained using scripts (Figure 8) that they could use in their approaches and the process of using Nudge Videos in approaches - both for organ (usually face-to-face with NOK) and tissues (typically via phone) - has been institutionalized. Examples of successful use of Nudge Videos are in Figure 9.

Some OPOs track the (weekly, by DC) performance of Nudge Videos. Here is an example:

Overall Total: Videos shown 10 times with 7 authorizations for an overall authorization

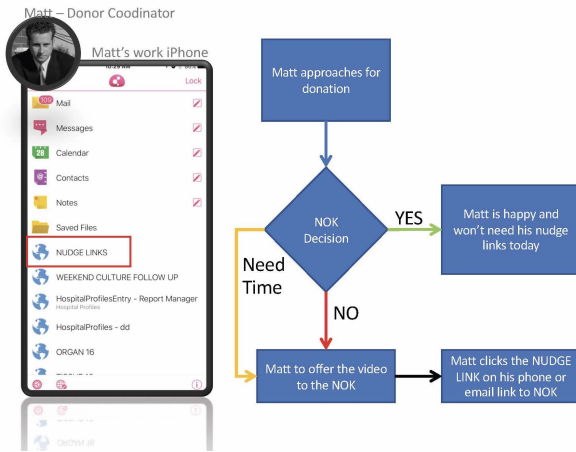
⁷This video was co-developed with New Jersey Sharing Network: <https://www.youtube.com/watchv=D2R2dt51ZgAt=1s>

⁸Videos are in English and Spanish: <https://youtu.be/7eYTSToZKuQ> and <https://youtu.be/ACwMSRq2Nfo>

- **Sunday, September 18th, 2016.**
- **Potential Deceased Donor: Female, 46, Black, Baptist.**

- **10:15 a.m.** – Received a call from triage saying that the family wanted to withdraw shortly. Large family presence.
- **11:25** – Arrived. Huddled with the room nurse and head of ICU. Both said there have been around 50 people there since the patient was admitted 2 days prior (siblings, partner, church, neighbors/co-workers/friends).
- Both said the family had been “all over the place”, the patient’s siblings wanting to withdraw but not wanting to pressure the very emotional son and father. They had just made the patient DNR but wasn’t sure if they were also withdrawing.
- **11:50** – ICU attending said that she spoke to the family, they want to withdraw at around noon, comfort care ordered.
- **12:00** – Asked attending to introduce me. She pulled the son and his dad into the conference room and was present during the approach. Dispelled myths about donation including mutilation fears. Discussed timing and “she’s already been through enough.”
- Their primary concern ultimately was timing – they’d already wrapped their heads around withdrawal, the entire family/community was gathered to say their goodbyes. They said they’d have to talk to other family members.
- **12:27** – Offered and texted Nudge video to both son and his dad, said it was a short video about other families like theirs who’d considered donation. Encouraged them to take a few minutes to watch it and that could share it with other family members.
- **12:27:35** – Nudge Link was activated.
- **12:45** – Son and father returned and wanted to move forward with organ donation.
- **13:26** – Obtained written consent.

Figure 7: Example of the use of Nudge Video in an Approach.



Thank you so much for taking the time to talk with me today. I would like to offer my condolences for your loss. What matters most to us is that you are able to make an informed decision. Would you please consider watching this short testimonial from families who, just like you, were faced with this decision?

I think it might be helpful for you to hear how some other families, in similar situations, handled this decision.

The families we’ve worked with felt compelled to share their experience when offered the donation option. I think you’d benefit from hearing what they had to say about it....

Figure 8: Process and Script for Nudge Video use in an Approach.

rate of 70%.

Showed the Tissue Video 9 times with 6 authorizations after family watched for a 66.7% authorization rate. (8 families watched the tissue clip, 6 said yes and 2 declined. 1 family was sent the clip, but no contact was ever made.)

Showed the Organ Video 1 time and got 1 authorization for 100%.

Each organ consent can help up to 8 patients, and each tissue consent can help up to 75 patients. There are 52 weeks in a year, and 58 OPOs with several DCs at each OPO: You do the math.

4 So, I am a Market Designer now?

Market Design recognizes that well-functioning markets depend on detailed rules. *Market Designers*

Deceased: 69, Male. NOK: Brother and niece. Niece was located in MN. Approached via phone. Patient from Kenya. Patient has living siblings in Kenya. Niece and DC made international call to NOK in Kenya; phone consent obtained.

Deceased: 57, Male, African American. Wife (NOK) and son were undecided due to patient not being on the registry. Early evening. Family had time to think. After the video, they were more open and talkative about patient being a kind person and would want to give.

Deceased: 42, Male, Hispanic. NOK: Brother. Wanted to speak with other family members. Called back in 30 minutes. Brother thanked me for the video, said it was "nice" and we continued with paperwork for consent.

Deceased: 24, Female, Asian. NOK: Mother. Family initially did not want to donate. After viewing Nudge Video, family pleaded with me to have her be an organ/tissue donor.

Deceased: 78, Male, Catholic. NOK: Wife and son. Family couldn't decide on whether or not to donate. After viewing Nudge Video, they all agreed that it would be in the best interest of the patient and his legacy to donate.

Deceased: 61, Male, African American, Christian. NOK: Wife. Family is having a difficult time accepting patient's death and are very distrusting of hospital staff due to conflicting information from Care team. The family was also witnessed viewing a anti organ donation video in the waiting room, which they later invited me to view. Family then viewed Nudge Video. Consented.

Figure 9: Examples of successful use of Nudge Video.

try to understand these rules and procedures well enough to improve and enhance them or to build markets from scratch when they're missing. At the time I created OrganJet and conceived of Nudge Videos, I did not think of my innovations in this framing. In 2017, I spent some time at Stanford, and having coffee with Al Roth was a frequent afternoon affair, where we discussed religion, ethics, economics, operations research, in the context of organ transplantation. On one of those occasions, he autographed his book *Who Gets What - and Why* (Roth 2015) thus:

For Sridhar,
from one Market Designer to another,
with warmest wishes, Al (5 April 2017)

Well, Al jointly shared the 2012 Nobel Prize (with Lloyd Shapley) *for the theory of stable allocations and the practice of market design*. So, yeah, I suppose I am a Market Designer now!

How did I get such detailed understanding of procedures and appreciation of nuances in a field that was new to me? I have collaborated extensively with Transplant Centers, Surgeons, Physicians, Donor Coordinators, Medical Ethicists, Philosophers, Insurance Companies, Jet providers and Organ Procurement Organizations (OPOs) over the past decade, so much so that I feel I am no longer an outsider (see Figure 10). I would like to highlight a few collaborations and avenues that have allowed me to gain a deeper understanding of the system as well as provided me opportunities to communicate my ideas to the organ transplant community. In 2012, I was invited to present at MGH Grand Rounds where transplant surgeons explained many commercial aspects related to transplants. In 2016, I was on the organizing committee of a Johns Hopkins hosted *When Organ Transplantation meets Operations Research* conference that brought together transplant physicians and researchers from our community. In 2019, based on a collaboration with MGH transplant physicians, we presented an approach to make liver transplant more equitable between patients who have cancer (HCC) and those who do not, at the annual ASTS Conference (Rickert et al. 2019). In 2021, I was invited to provide my views (see Appendix B) to *The Committee on A Fairer and More Equitable, Cost-Effective, and Transparent System of Donor Organ Procurement, Allocation, and Distribution*. Beyond OrganJet and Nudge Videos, I discussed disparity due to size, that affects gender (women) and race (Asians and Latin Americans) disproportionately. As remedies, I suggested adding exception points to improve equity (Bernards et al. 2022), and also recommended that the use of Split Liver Transplantation (SLT) be expanded (Kim et al. 2021). Both of these studies were done in collaboration with UCSF transplant physicians.

Year	Activity
2011	Founded OrganJet
2012	Al Roth blogs on his Market Design site on OrganJet Founded Guardian Wings MGH Grand Rounds
2013	HBS Case on OrganJet and GuardianWings Guest Speaker at HBS 2013-2019
2014	NEJM, Atlantic articles on OrganJet
2015	INFORMS Pierskalla Award for OrganJet CBS News coverage of OrganJet Discussed OrganJet as Operationalizing Rawls with Amartya Sen Presentations at UPMC, Highmark-AHN
2016	White House Invitation highlighting Nudge Videos AMAT Conference Keynote: Nudge Videos Johns Hopkins Conference on OR and Organ Transplantation
2017	HKS-WEF Schwab Social Entrepreneur Program Presentations at UCSF, Stanford Lucile-Packard
2018	Co-edited <i>Handbook of Healthcare Analytics</i> OrganJet featured in <i>The Craft of Creativity</i>
2019	REACH presented at ASTS
2020	AOPO Keynote on Nudge Videos Aspen-Ross Keynote: Re-imagining US Transplantation
2021	Ethics of Split Liver Transplantation (SLT) NASEM Committee on Organ Transplantation
2022	Exception Points for Gender Equity

Figure 10: Activities of an Academic Philanthropist in Organ Transplantation: 2011-2022. In boldface are a few activities with the transplant community that are mentioned in the text.

Many challenges remain. NASEM (2017) and NASEM (2022) detail several important priorities, from which I will highlight just three here: (1) Why is there continued organ wastage when there is such a shortage? (2) How to increase consent from minorities (African Americans, in particular) who are themselves facing long wait times? (3) How to equitably and efficiently manage multi-organ transplant situations? Queuing models - along with (a) game theory to model strategic interactions (what we call queuing games (Akan 2018), like in the case of OrganJet), or (b) with optimal control, to study equity and fairness, as has been used to reduce gender disparities in liver transplants (Celdir et al. 2024) - have been a very powerful contribution from our field to the improvement of organ transplantation, and I expect they will continue to play an important role. Optimization models using mathematical programming have also been useful (Akan 2024). I believe that executing field experiments, similar to Randomized Clinical Trials (RCT), carefully designed based on scientific theories of human behavior (like the Nudge project, Kush and Tayur (2022)) and rigorously evaluated empirically, can also be an effective methodology in this setting. Regardless of methodology used, or the specific topic selected for study, it is beneficial to collaborate closely with the transplant community, who I know are eager to interact with us to address urgent and important problems. Furthermore, given the complexity of the situation, where payers (private insurance and CMS), providers (transplant center leadership), physicians (and transplant coordinators), and policy makers (Federal and State) interact strategically, our community can benefit from themselves becoming strategically sophisticated, so as to nimbly navigate through the healthcare ecosystem (Dai and Tayur 2018, 2020) and be able to conceive and implement consequential innovations that can substantially improve many lives.

Throughout my professional career, I have sought to transcend the *Either/Or* dichotomy with a *Both/And* viewpoint, as I was quoted in Cronin and Loewenstein (2018):

Elegance is not something that should be considered discretionary, but rather an intrinsic feature of a proposed solution. The tragedy in some academic circles is that they make elegance the "whole thing," losing sight of the problem to be solved, while the pragmatic sort do not have the luxury for aesthetic considerations. The intersection of elegance and effectiveness is the essential intellectual challenge.

I hope that this article encourages our community to be more virtuous, and apply our skills, talent, and energies to tackle important societal problems, not just in organ transplantation (or healthcare), but more broadly. Indeed, I agree with Clinton (2007):

One of the greatest gifts anyone can give is a useful skill. Most of us know how to do something not everyone can do as well as we can.

Physicians have *Doctors without Borders*. Lawyers have *Innocence Project*. What about us?

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Appendix A

A fundamental model for capturing the dynamics of waiting for transplantation is an overcrowded queuing model, with arrival rate λ (of patients) greater than the service rate μ (organ supply) with abandonment (of rate γ), representing patients who leave the queue before receiving transplantation. The most tractable version of this model is its *fluid limit*, a deterministic approximation which captures the average number in the system (and wait time), in steady state. Letting Q be the average number in the queue, W the average wait time and $\phi(= \frac{\mu}{\lambda})$ the probability of receiving a transplant, we have, by flow balance equation, $\lambda = Q\gamma + \mu$, resulting in $Q = \frac{(\lambda-\mu)}{\gamma}$, and, by Little's Law, $W = \frac{Q}{\lambda} = \frac{(1-\phi)}{\gamma}$.

Ata et al. (2016) builds on this model by representing the US Transplant System as a network of such queues, $i = 1 \dots N$, each i representing a Donor Service Area⁹ (DSA), with its own arrival rate λ_i , service rate μ_i and abandonment rate γ_i . Selfish routing means that each patient will choose to multiple list to maximize their life expectancy, knowing that everyone else will be doing the same. This will (under reasonable technical assumptions) equalize wait times across the network, if all patients could list anywhere, and in as many locations. A more realistic situation is to suppose that (a) only locations that are not too far off are considered for multiple listing (about 700 miles, as flying time on a light jet will be under two hours), (b) that most people list in at most one other location (dual-listing), and (c) only $0 \leq \pi \leq 1$ fraction of patients will do so. This leads to a reduction of geographic coefficient of variation of wait times (GCV_w) or variation of likelihood of transplantation (GCV_ϕ), but may not eliminate the geographic disparity entirely. Based on data¹⁰ about the US Transplant System, these metrics as a function of fraction π that choose to multiple list can be numerically computed (see Figure 11).

⁹If a DSA has more than one transplant center, they are all combined into one in the model.

¹⁰<https://optn.transplant.hrsa.gov/data/>

π	0	0.05	0.10	0.15	0.20	0.25	0.50
GCV_w	24.8 %	21.3 %	18.3 %	15.7 %	14.7 %	13.7 %	12.4 %
GCV_ϕ	24.9 %	20.5 %	17.1 %	13.4 %	10.9 %	8.6 %	5.8 %

Figure 11: Sensitivity analysis of geographic disparities in wait times and likelihood of transplant as a function of fraction that choose to dual list at a center that is less than 700 miles away. See Ata et al. (2016) for details.

A diffusion approximation is also analyzed in Ata et al. (2016). The equilibrium outcome under the diffusion approximation is a second-order perturbation of that under the selfish routing formulation, further supporting the finding that multiple listing improves geographic equity.

Appendix B

The Committee on A Fairer and More Equitable, Cost-Effective, and Transparent System of Donor Organ Procurement, Allocation, and Distribution met on July 15th, 2021. These were my remarks.

Thank you for inviting me.

I address two main areas of inequity in access - Geographic and Gender – and suggest implementable operational methods to remedy them. Additionally, I propose a zero-cost, easy-to-implement video intervention for the first order problem of lack of supply that can be immediately effective.

Geographic disparity of access is well documented. Rather than send an organ to the patient, why not take the patient to the organ? That is what the social enterprise OrganJet does. Simply put, this is smart dual listing combined with on-demand jet travel. How is this feasible at scale? There is considerable supply of excess capacity from over 18000 under-utilized jets that can land in one of the 5500+ airports across the country. Where direct commercial flights are available between origin and destination cities, private jets are not needed, except possibly at nights. Our published research indicates that geographic disparity can be reduced. Additionally, greater number of more appropriate kidney transplants can take place due to more organs retrieved and less organs discarded. Savings on dialysis costs more than make up for increased costs of travel and second listing. Making smart dual multiple listing part of standard of care, for kidney transplants, by

private and public insurance is a win-win for patients and payers.

Gender disparity in liver transplantation is related to size mismatch between patients and available organs, correlated strongly with height of the recipient. There is now 30% less chance for a woman to get transplanted compared to men. Our work, in collaboration with UCSF Transplant Group, using LSAM, indicates that providing 1-2 additional points to the shortest 8-10% of patients can alleviate this inequity without appreciable impact on the rest of the population. This is easy to implement. A longer-term possibility to remedy this disparity is Split Liver Transplantation (SLT).

The first order problem in transplantation is lack of supply. First Person Consent (FPC) rates have plateaued, and morbidly, one has to wait for such a person to die in a medically acceptable manner relatively quickly. This can hardly be considered an acceptable solution to the pressing problem of today. There is a much larger opportunity to increase supply right now through second person consent, from legal next-of-kin (NOK). Our field experiment using videos that are already freely available (in English and Spanish) with Nevada Donor Network indicates that this intervention is a zero-cost option that results in nudging next-of-kin towards increased consent. Widespread use of such videos across Organ Procurement Organizations (OPOs) can be immediately helpful nationwide.

Thank you for the opportunity to present.

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