

Economic trends and organ donation rates in the USA: An ecological analysis

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Abstract

The ecological association between several economic indicators and organ donation rates in the USA were examined for the years 1988 to 2012. A strong, positive correlation was identified between GDP per capita and all organ donation rates, except for heart donation, for which a strong, negative correlation was found. These results suggest that economic downturns may be associated with reductions in organ availability, except for heart allografts.

Introduction

At any given moment, there are over 100,000 people in the USA waiting for an organ donation, with 140 more people added to the waitlist each day.¹ Conversely, about 5000 are waiting for an organ donation in Canada.² While the demand for organs grows, the donation rate has not matched that demand. Exploring the factors affecting organ donation rate is an important research focus, and could help to devise strategies for encouraging organ availability. Understandably, studies of donation patterns in the USA are often done within the context of strategies to increase the supply of available organs, while studies of large-scale societal factors in organ donation trends are infrequent.³

The factors that have been found to influence individual organ donation include personal, social, racial, age-related, and cultural factors.⁴ Those with fewer financial resources are also less likely to be registered for organ donation.⁵ But the extent to which societal wealth affects a population's penchant for deceased donation is still not well understood. It would seem reasonable that lesser societal economic wealth would translate to lessened individual wherewithal, and consequently a decline in organ donation rate. However, a recent comparison of organ donation rates, both living and deceased, within Greece and other European countries affected by the regional economic downturn, suggests that organ donation was relatively unaffected by the 2008 European financial crisis in the countries maintaining relevant policies to encourage donation.⁶

The existing explorations of the question regarding the factors that influence organ donation have been ecological, with analytical granularity limited to country-level data. Mizraji et al. found that donation rate was not significantly correlated with the United Nations Human Development Index (HDI), but that there does exist a weak relationship between donation rates and gross domestic product (GDP) at the national level.⁷ Similarly, Bendorf et al. found that the HDI and national GDP are associated with deceased kidney donation, but not living donation.⁸

Within this study, we sought to explore an ecological relationship between organ donation rate and specific measures of societal wealth, GDP, and health insurance prevalence rates, within the USA alone, with state-level indicators as our analytical elements.

Materials and Methods

National and state-level organ donation data was obtained from the Organ Procurement and Transplantation Network (OPTN) for the period between 1988 (the earliest year for which data was shared) and 2014.⁹ National economic data was obtained from the United States Census Bureau and the World Bank.^{10,11} The donation data described the number of deceased adult donors for the following organ types: kidney, liver, pancreas, heart, lung, and intestine. An individual donating more than one organ was counted once as a single donor. We did not have access to donor demographics or any individual characteristics, including whether donors were extended criteria donors (ECD), non-extended criteria donors (non-ECD), donation after cardiocirculatory death (DCD), donation after brain death (DBD), or donor ethnicity.

The economic data described measures of wealth in the United States within the last 26 years, with a focus on proportions of people with health insurance, as well as national and state-level nominal GDP per capita and employment rate. Insurance levels were established from the Survey of Income and Program Participation (SIPP). For our purposes, an individual was considered insured if he or she was covered under either a private or government program, under the definitions of SIPP. These indicators were chosen because they are generally well accepted as measured of societal wealth relevant to health economics. Though cited studies employed HDI, this indicator is not computed for individual states of the USA.⁷ Note that all analyzed databases include US residents, irrespective of citizenship or immigration status.

Bivariate and multivariate analyses were used to examine the ecological relationships between organ donation rates and economic indicators. Pearson's correlation coefficient was used to describe the relationship between organ donation and unemployment rate, insured rate, and GDP per capita. Multiple linear regression was

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used to model the associations of more than one economic factor with organ donation rates. All statistical tests were conducted using IBM SPSS Statistics 20.

Table 1. Coefficient of determination (r^2) of linear regression of national level organ donation rates between 1988 and 2012 in the USA.

Organ	Coefficient of determination (r^2)
Heart	0.328
Intestine	0.754
Kidney	0.915
Liver	0.863
Lung	0.864
Pancreas	0.379

Table 2. Pearson's correlation coefficient (r) of national level organ donation rates and selected economic indicators between 1988 and 2012 in the USA.

Organ	GDP per Capita	Insured Rate	Unemployment Rate
Heart	-0.547	-0.127	-0.112
Intestine	0.835	0.226	0.054
Kidney	0.956	-0.048	0.312
Liver	0.920	0.118	0.155
Lung	0.927	0.049	0.474
Pancreas	0.562	0.243	-0.262

Table 3. Summary of multiple regression for factors associated with US heart donation between 1988 and 2012.

Covariate	Beta coefficient	p-value
Insured Rate	-0.136	0.435
GDP per capita	-0.559	0.003

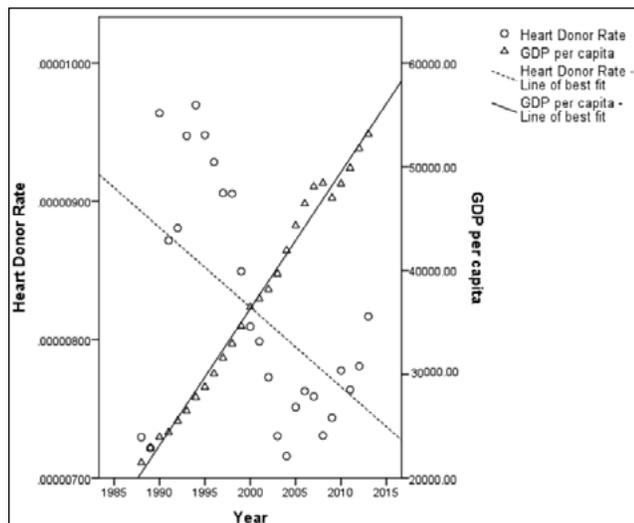


Figure 1. Relationship between national level heart donation rate and GDP per capita between 1988 and 2012 in the USA

Results

Donation rates for all major organs showed an upward trend from 1988 to 2012, with the growth remarkably linear (r^2 values above 0.7) for all except heart and pancreas (Table 1). The denominators indicated represent the potential donor pool, i.e., the total base population of each state or nation. Donation rates were well correlated ($r > 0.5$) with GDP per capita, but not with other economic indicators (Table 2). The relationship between economic growth and donation rate was strongly positive for all organs except for heart donation, which was strongly negatively correlated with GDP per capita (Figure 1). Collinearity was particularly strong for kidney donation (Figure 2), for which 91% of variation (r^2) in donation rate could be explained by economic changes. All correlation coefficients were statistically significant ($p < 0.05$).

Multiple regression analysis was performed to further explore the negative relationship between heart donation rate and GDP per capita, specifically to determine if much of the effect of GDP could be explained by employment and insurance status. A high degree of collinearity ($r > 0.3$) was found between insurance rate and both GDP per capita and unemployment rate, forcing the removal of the latter from the final model. After this modification, GDP per capita was still found to be negatively significantly associated with heart donation rate, when adjusting for employment ($p = 0.003$, see Table 3).

Discussion

The results suggest a strong relationship between organ donation and nominal GDP per capita in the USA, at least at the national level. It is unclear whether living donation rates would parallel deceased donation rates, with respect to a relationship with GDP. Thus, these results are not generalizable to living donation. One problematic exception in this otherwise consistent and strong pattern is that heart donation is inversely correlated with GDP. We can offer no detailed hypothesis to explain this difference, except to comment on the limited extent to which ecological studies such as this are able to discern trends among individual behaviours.

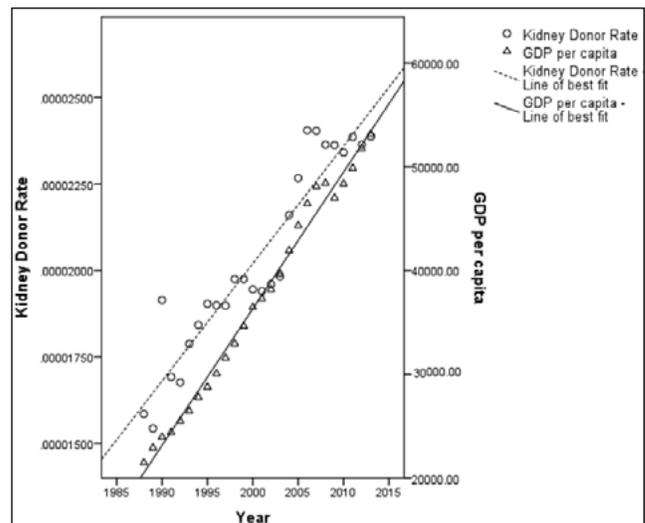


Figure 2. Relationship between national level kidney donation rate and GDP per capita between 1988 and 2012 in the USA.

According to our multivariate analysis, the relationship between GDP and donation rate is not gated by employment rates or insurance status. While all three factors enjoy high collinearity, we had posited that GDP was merely a proxy measurement for other health-relevant expressions of wealth, most notably whether residents benefit from insurance. These results suggest that that is not the case. Development indicators, such as the HDI, are not computed for the state-level, nor did we have access to donor demographics or individual characteristics, such as ethnicity and type of donor. Access to these data might have helped elucidate the true nature of the economics-donation relationship at the state-level, with increased granularity, by adding more complexity to our multivariate model.

It is interesting that changes in heart donation rate coincide with the implementation of donation after cardiac death (DCD) in the 1980s. DCD is defined as donation after cardiocirculatory determination of death, with donors called “non-heart-beating donors”.¹² When DCD was introduced, there was an expansion in the donor pool, and an increase in organ donation was observed.^{13,14} Before DCD was used, donation after brain death (DBD) was the only source of hearts. As DCD use rose, DBD use plateaued.¹⁴

The extent to which DCD complicates the donation landscape is yet unclear. The expansion in the donor pool to include DCD organs appears to be independent of economic growth, and probably due more to technological advancements. A suggestion for future studies would be to stratify DBD versus DCD donation rates to help account for this complicating variable. Our present variable set is inadequate for the task.

The strong relationship between population-level donation rates and national economic wealth is not surprising, given that there is extensive literature finding that positive attitudes toward organ donation are associated with higher socioeconomic status, and conversely, negative attitudes are associated with lower economic status.^{15,16} While the present study focuses solely on deceased donors, it is important to note that lower income has been proposed as a factor leading to lower living organ donation,

due to the out-of-pocket costs of donation, such as lost income in taking time off of work for surgery and recovery.¹⁷ This information led to the finding that providing accommodations for socioeconomic impactors, such as earning various reimbursements and transportation refunds, can improve donation trends.¹⁸ This does not apply for deceased donation, however.

Others suggest GDP and related factors allow for a high-functioning organ donation and transplantation program, which then leads to increased organ donation rates in both deceased and living donors.⁸ Education may be a mediating factor, as post-secondary education is associated both with having more awareness of organ donation and with increased likelihood of becoming a living organ donor, which also applies to deceased donation.^{16,19,20} The quality and accessibility of education programs is, of course, well-associated with societal wealth.²¹ One aspect of education that might be relevant is health literacy, as it can affect both economic status and donation decisions, making it a classic confounder. The ecological nature of our data limits our ability to provide more than suppositions about the potential causal link between societal wealth and organ availability, and the extent to which various individual and societal factors are confounding this perceived link.

Of course, ecological analyses are innately flawed in that they cannot account for individual-level circumstances, nor many forms of confounding. Thus, we should be hesitant to draw conclusions from such analyses, as we cannot examine the impact of unique policies or circumstances arising within each state. As well, GDP does not allow for comparisons of the wealth disparity between individuals or small groups, as it is a measure of larger population wealth. However, the very strong measures of association derived from these findings do suggest that, at the very least, transplant professionals should expect organ availability to trend with changing economic profiles. Moreover, our analysis does not explore the effects of economic downturns at the state level, and how such instances may affect both the supply and demand of organs. For example, motor vehicle accidents tend to decrease in times of recession, perhaps leading to a lesser supply of organs.²²

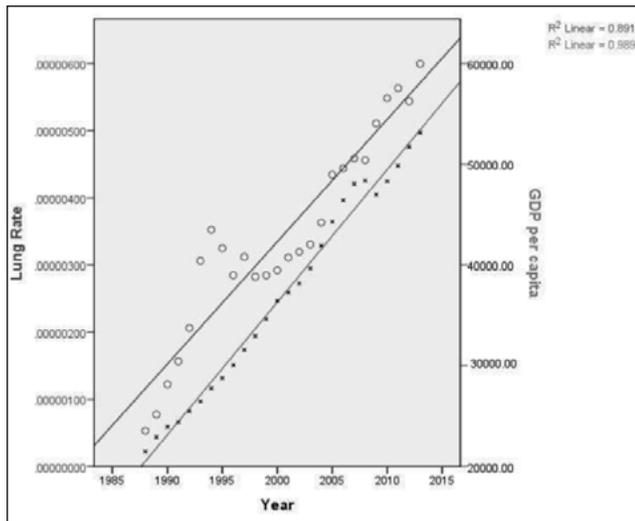


Figure 3. Relationship between national level lung donation rate (o) and GDP per capita (x) between 1988 and 2012 in the USA. Pearson correlation coefficient (r) = 0.927.

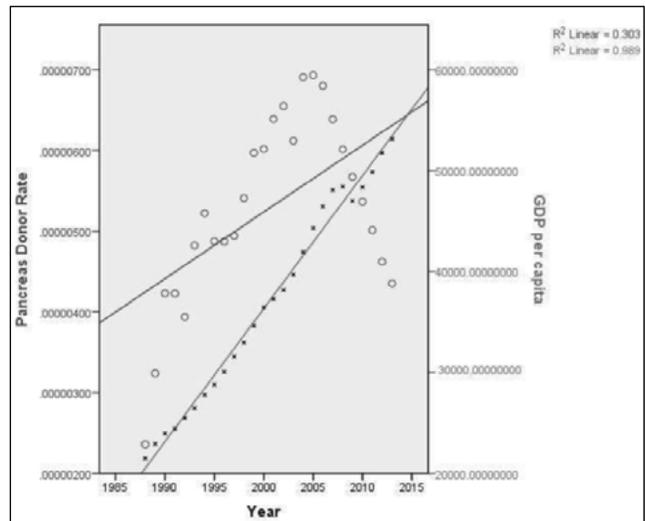


Figure 4. Relationship between national level pancreas donation rate (o) and GDP per capita (x) between 1988 and 2012 in the USA. Pearson correlation coefficient (r) = 0.562.

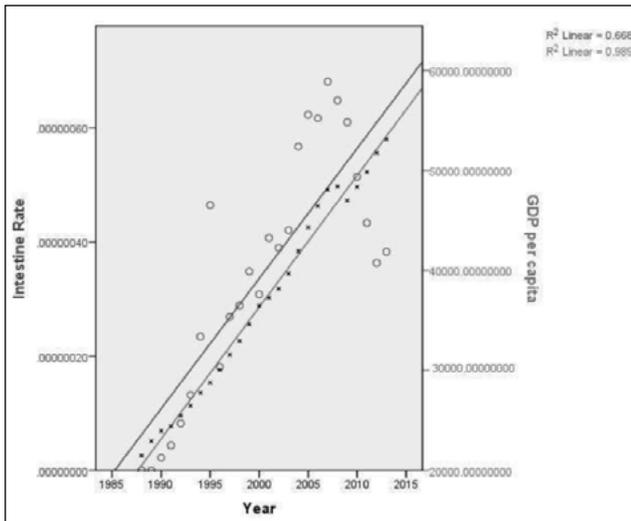


Figure 5. Relationship between national level intestine donation rate (o) and GDP per capita (x) between 1988 and 2012 in the USA. Pearson correlation coefficient (r) = 0.835.

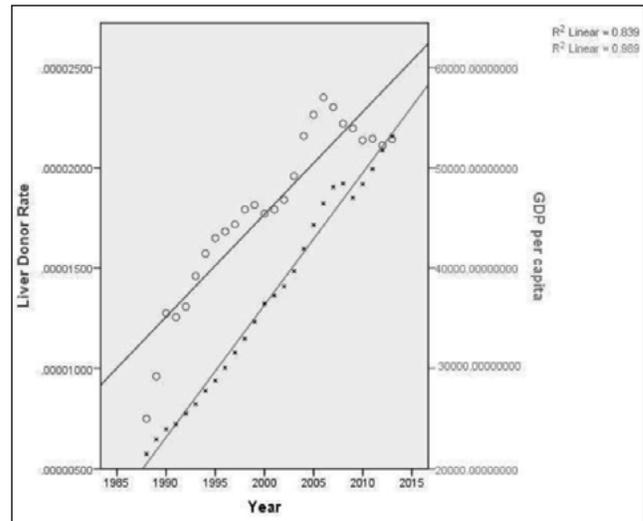


Figure 6. Relationship between national level liver donation rate (o) and GDP per capita (x) between 1988 and 2012 in the USA. Pearson correlation coefficient (r) = 0.920.

Our results should be considered a hypothesis-generating exercise that might lead to further questioning of population-level trends that might correlate with organ supply and demand, and certainly not an indication of an actual causal relationship. The development of specific policies and programs, therefore, should be based upon follow-up investigations seeking to identify the likely mechanisms and pathways by which wealth affects an individual's willingness to donate.

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