

Can kidney deceased donation systems be optimized? A retrospective assessment of a country performance

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Background: The intensive requirement of organs for transplantation generates the need for higher rates of donation. **Methods:** Using the national database of diagnosis-related groups for 2006, the global annual 2006 in-hospital mortality of 34 hospitals with organ-retrieval schemes was evaluated. Potential donors were estimated excluding patients aged <1 year or >70 years and presenting International Classification of Diseases, Ninth Revision codes that contraindicated organ donation. **Results:** We identified 3838 potential donors (12.6% of in-hospital deaths); 46% came from eight hospitals, 80% came from the larger hospitals and 21% from intensive care units (ICU). In hospitals with a neurosurgical department, an office coordinator of procurement and transplantation (OCPT), a transplant centre and co-location of neurosurgical and transplant centre, we identified, respectively, 54, 30, 32 and 30% of all potential donors. The causes of death were 23% cerebrovascular disease, 3% cerebral tumour, 2.6% anoxic lesion and 2.5% head trauma. In the same period, there were 189 effective deceased kidney donors with traumatic diseases as the main cause of death. The mean conversion rate was 4.9% and was associated with demographical and hospital characteristics. Age of potential donors, existence of OCPT or transplant centre, ratio between ICU and hospital acute beds and mortality from labour accidents were predictors of being an effective donor. **Conclusions:** Health policies need to maximize the conversion of potential to effective donors and the performance of organ donation systems must be considered as an index of the quality of care.

Introduction

In Western Europe, there are more than 40 000 patients on waiting lists for transplantation with a mortality rate of 6.3% while waiting for a kidney.¹ Organs from extended criteria donors have increasingly been used and, while a condemnable practice,² organ trafficking, transplant commercialization and transplant tourism area a reality today.

Portugal, a country with 10.6 million inhabitants, has an annual incidence of 234 per million population (pmp), a prevalence of 1600 pmp of chronic kidney disease (CKD) stage 5d; 2500 people are waiting for a kidney transplant (Portuguese Society of Nephrology, 2009). Contributing causes are ageing (17.6% population aged ≥65 years), high prevalence of arterial hypertension (42%)³ and of diabetes mellitus type 2 (12.4%).⁴ The rate of donation has been increasing, reaching 31 pmp in 2009, placing Portugal in second place in the world. In 2009, 563 renal transplants (53 ppm) were performed. The definition and the methodology for assessment of brain death are legislated. Since 1994, Portugal has a presumed consent system supported on a national registry of refusal to organ donation (RENDA). By the end of 2008, there were 37 461 people registered as no donors (0.35% of population). Families of deceased donors are approached as negative public opinion may be harmful for organ donation. The rate of refusal is 6%.¹ There are five office coordinator of procurement and transplantation (OCPT) located in central hospitals, two in the North, one in the Centre and two in the South of the country; each one is articulated with a group of hospitals that meet the legal requirements for recovery of organs. These OCPTs were integrated in the Portuguese Organization of Transplantation (OPT) and, since May 2007, in the Authority for Blood and Transplantation Services (ASST). The evaluation of potential donors at national level is needed to assess fairly the performance of individual Organ Procurement Organization (OPO) and of the organizational network as a whole.⁵ Some authors argue that the ratio between effective and potential donors is a better metric than effective donors ppm because it is independent of population

characteristics⁶ and enables comparison of performance of OPOs among countries.⁷

This study aims to assess the number, characteristics and causes of death of potential donors compared with effective donors. It will seek to identify the individual, hospital and demographical factors associated with the conversion rate for the year 2006.

Methods

Data sources: hospital data, including the diagnosis-related groups (DRG) 2006 database, were obtained from the Ministry of Health, Central Administration of Health System (ACSS). This entity centralizes the data of all hospital cases in public hospitals which are classified by a trained physician into one of DRGs based on International Classification of Diseases, Ninth Revision (ICD-9 CM) diagnoses. Demographical data were obtained from the National Institute of Statistics. Recovery hospitals were identified from the Report of OPT 2005–06. The characteristics of effective donors, and organs not usable by the teams of organ recovery or not accepted by transplant centres were provided by ASST. The authors used the last available reports of ACSS and OPT and no significant alterations were introduced in the deceased organ procurement programme since the data were collected.

A retrospective study was conducted to analyze mortality in the 34 hospitals with organ recovery. Potential donors were defined as patients aged >1 year and <70 years, died in hospital and deemed medically suitable for organ donation.⁸

Two lists were set up, one with the hospitals with organ recovery and another with the exclusion criteria: infectious and neoplastic diseases, diabetes mellitus type 1, renal chronic disease and risk behaviours.

In the national DRG database, the data of all hospitalizations were selected using three criteria: code of destination = death; age ≥1 and ≤70 years and hospital with organ recovery, generating a list of possible donors. Then, the ICD-9-CM codes that contraindicate donation were checked in all diagnoses (maximum possible: 20) that

classify each episode of hospitalization, generating the potential donors. The distribution by cause of death: cerebrovascular diseases (CVA), head trauma, brain tumour and anoxia were analysed.

A second database was constructed considering each hospital as a unit of observation to assess the factors affecting the number of potential donors and the conversion rate defined as the ratio between the number of effective donors and potential donors, and used as a proxy for each hospital's donor efficiency.

Selected characteristics of the hospitals were central vs. district hospitals; number of health professionals; number of intensive care units (ICUs) beds; acute beds stratified by number: <150, 150–350 and >350; the case-mix index (a measure of the costliness and complexity of cases treated by a hospital); existence of neurosurgical department, OCPT or transplant centre. Demographical data included an ageing index (number of residents aged ≥ 65 years/100 residents <15 years); a masculinity index (number of males/100 females); population density; number of physicians and nurses/100 000 population; mortality rates from cardiovascular and neoplastic diseases, and road and labour accidents.

The performance of OPOs was evaluated by the conversion rate and the potential donors/pmp stratified at national, regional and OCPT level.

Statistical analysis

Descriptive statistics were computed for all variables. Results are expressed as arithmetic mean and 95% confidence intervals for normally distributed samples, or median with percentiles 25–75 for skewed variables. Student's *t*-tests or analysis of variance were used to compare the means between samples or their non-parametric equivalents. Pearson correlation or its non-parametric equivalent Spearman correlation coefficients were used to measure the association between continuous variables. Chi-squared test was used to test for associations between discrete variables. We used logit regression for grouped data to investigate the relationship between becoming an effective donor and several independent predictor variables. Statistical significance was assumed for $P < 0.05$. Statistical analysis was performed with SPSS, version 13.0. Logit regression was carried out using STATA, version 8.

Results

In the 34 hospitals analysed, there were 30 488 deaths, corresponding to 70% of all in-hospital deaths in Portugal in 2006. For patients aged 1–70 years, there were 9752 deaths; 5914 of which had ICD-9-CM codes that contraindicated organ donation. In two hospitals, no deceased donor met the inclusion criteria. We identified 3838 potential donors from 32 hospitals, corresponding to 0.5% of the episodes of hospitalization and 12.6% of all in-hospital deaths. Demographical and hospital characteristics are given in table 1.

The median number of potential donors per hospital was 102.5 (percentile 25–75: 65–176). We identified 1801 potential donors (46% of total) in eight hospitals, of whom 536 were admitted to ICUs (65% of all ICU admissions).

Applying to 3838 potential donors the ICD-9 CM codes representing the pathologies that often evolve to brain death,⁹ we identified 608

deaths. This subgroup of potential donors will be called realistic potential donors. A diagram is shown in figure 1.

In hospitals with neurosurgical department, OCPT, transplant centre and co-location of neurosurgical department and transplant centre, we identified, respectively, 2090 (54%), 1173 (30%), 1221 (32%) and 1147 (30%) of potential donors.

The number of potential donors correlates with the following hospital characteristics:

- Number of nurses ($r = 0.807$; $P < 0.001$)
- Number of acute beds ($r = 0.806$; $P < 0.001$)
- Number of physicians ($r = 0.768$; $P < 0.001$)
- Number of ICU beds ($r = 0.740$; $P < 0.001$)

No correlation was found with ageing index, traffic accident and rates of mortality from cardiovascular and neoplastic diseases.

In 2006, there were 189 effective kidney donors, mainly male (65%), with a median age of 44 years (percentiles 25–75: 28.5–56). Four kidneys were considered unusable by the recovery teams, eight kidneys were refused by the transplant centres, and so 366 kidney grafts were implanted.

The number of potential donors correlates with the number of effective donors ($r = 0.626$; $P < 0.001$).

In effective donors, the cause of death differs with age ($\chi^2 = 35.267$; $P < 0.001$) and sex ($\chi^2 = 15.483$; $P < 0.001$).

The mean of the conversion rate was 4.9%. The conversion rate directly related with (i) the number of physicians ($r = 0.501$; $P < 0.01$) and nurses per 100 000 population ($r = 0.499$; $P < 0.01$), (ii) the absolute number of hospital physicians ($r = 0.464$; $P < 0.01$), (iii) the number of beds in ICUs ($r = 0.464$; $P < 0.01$), (iv) the ratio between ICUs and acute beds in each hospital ($r = 0.496$; $P < 0.01$) and (v) population density ($r = 0.392$; $P < 0.05$). The conversion rate inversely related with the age of potential donors ($r = -0.641$; $P < 0.001$) and the index of masculinity ($r = -0.500$; $P < 0.01$).

The causes of death among effective and potential donors influenced the conversion rate (table 2).

Logit regression revealed that ICU/acute beds of hospital, age, existence of transplant centre, existence of OCPT and mortality from labour accidents in the areas of the hospitals were significant predictors for a potential donor becoming an effective donor.

Logit estimates were used to generate predicted values for a potential donor becoming an effective donor. There was a mean of 6.13 effective donors in all hospitals; the presence of OCPT determines an increase of this value to 12.11 and the inexistence of OCPT a decrease to 2.80.

The distribution of the potential donors and the performance of OPOs are shown in table 3.

Discussion

The increasing demand for organs for transplantation is in stark contrast with their scarce supply. The dearth of deceased organs requires strategies to optimize the performance of OPOs and to maximize the conversion of potential into effective donors.

To our knowledge, this is the first study that evaluates the availability of deceased kidney donors in Portugal and identifies the variables associated with organ donation contributing to optimization of the donation system.

Our methodology for estimating the deceased donors in Portugal differs from previous studies from other countries.^{5,6,10} Their assessment has been based on a review of medical records or on mortality rates of hospitals or ICUs.^{5,11} In this study, we first identified a theoretical maximum of 3838 kidney deceased donors (patients aged 1–70 years, died in hospital, medically suitable for kidney donation). To avoid the bias of overestimating the number of potential donors, we identified 608 realistic potential donors which corroborates the observation that less than 3% of the in-hospital deaths have a brain death diagnosis.¹ If all these patients were admitted to ICUs, excluding the 10% who have haemodynamic instability,⁹ we would get 548 effective donors corresponding to 54 ppm.

Table 1 Demographical and hospital-related characteristics of potential donors

Number of potential donors	3838
Male gender (%)	2554 (66.5)
Age (years)	
Male	Median 60 (percentile 25–75: 50–66)*
Female	Median 62 (percentile 25–75: 51–67)
Hospitalization in an ICU (%)	822 (21)
Hospitals with acute beds >350	3076 (80%)

* $P < 0.01$ vs. female

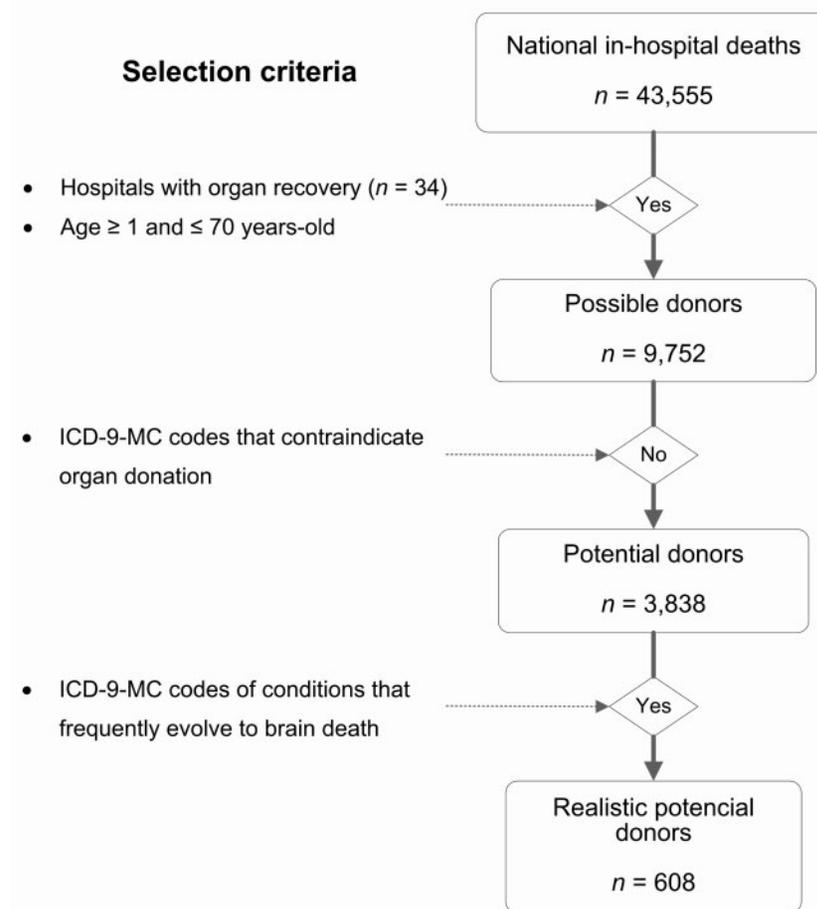


Figure 1 Methodological approach to in-hospital deaths audited

Table 2 Causes of death of potential and effective donors

Causes of death	Potential donors, n (%)	Effective donors, n (%)	Conversion rate, n (%)
Head trauma	95 (2.5)	88 (46.6)	93
CVA	886 (23)	82 (43.4)	9.3
Haemorrhagic stroke	436 (11)	78 (41.3)	18
Ischaemic stroke	450 (12)	4 (2.1)	8.9
Brain tumour	123 (3)	2 (1.1)	1.6
Anoxia	102 (2.6)	4 (2.1)	3.9
All other causes of death	2632 (68)	13 (6.9)	0.49
Total	3838 (100)	189 (100)	4.9

Table 3 Distribution of potential donors by country region

Country region	Hospitals	Potential donors	Potential donors/million people	Conversion rate (%)
North	9	1171	300 413	4.44
Centre	10	964	376 68	5.6
South	13	1703	402 07	4.87

Larger and central hospitals have, on average, more potential donors than smaller and district hospitals. Consequently, the number of health professionals and ICU beds were significantly associated with the number of potential donors. In hospitals with >350 beds, we identified 80% of potential donors well above the 38% reported by other authors.¹² The

observed 16% of potential donors in hospitals with 150–350 beds and 4% in hospitals with <150 beds should also be kept in mind as a considerable pool.

Like other authors, we found association between the pools of potential donors and the number of acute and ICU beds and the presence of specialized services.^{6,13} The data also indicate the effectiveness of donor identification in these large, highly differentiated hospitals and supports the validity of our methodology.

The lack of association between demographical characteristics and potential donors corroborates that the hospital mortality is a more accurate predictor of donor rates than population-specific mortality.¹³ Considering the presumed consent system, the low rate of refusal by families and the small percentage of non-donors, one would expect a higher conversion rate in Portugal. Studies about the impact of presumed consent system on the donor rates have shown conflicting results.^{14,15} A study about European countries evidenced no positive effect⁷ of presumed consent suggesting that this legislation alone will not ensure an increase of the supply of organs.¹⁵ Policy should take into account the process of organ procurement as this study showed.

In the hospitals with at least one organ recovered, the rate of conversion rises from 4.9% to 6.2%, and rises to 21.5% in the two paediatric hospitals. It seems that the act of donation is driven by a joint effort of parents and health professionals to save the lives of other children. Awareness of society to organ donation will extend the benefits of this act of solidarity to all age groups. The predictors of becoming an effective donor were presence of OCPT or transplant centre, critical/hospital acute beds, age and mortality from labour accidents after controlling for other variables. The association between OCPT and rate of conversion points to the reorganization of procurement coordinators. On average, 12 potential

donors in hospitals with an OCPT were converted to effective donors compared with two in hospitals without OCPT.

The association between the number of potential and effective donors points out that the hospitals with larger number of potential donors perform more transplants. However, we found a rate of conversion below percentile 25 in one of the hospitals with OCPT, and below percentile 5 in one of the hospitals with a transplant centre, suggesting that some hospitals could improve their performance.

In Portugal, the number of critical beds is 70.7/pmp (data reported by health authorities), whereas in Spain, the world leader of donation rates is 66.3 pmp.¹⁶ We must understand why the number of ICU beds in Portugal is not used as leverage. The clinical situation influences admission to ICUs. The evaluation of the performance of ICUs should be based on an algorithm. The number of effective donors as a percentage of potential donors must have a weighting greater than the mortality rate so that it does not overlap the decision for non-admission in cases of irreversibility of the clinical status of patients. The lack of resources can lead to loss of donors because the organ donation process in ICUs is labour intensive.¹⁷ The correlation between the numbers of potential donors and health professionals suggests the need of on-call work schedules. The health personnel will be available to be physically present whenever there is a potential donor.

The existence of transplant centre was a significant predictor reflecting the awareness for organ donation. It is accepted that young people who die of head trauma are the main source of deceased donors, neglecting the victims of CVA. This means an opportunity for changing this prevailing mentality and to assume a new attitude towards organ donation. Health professionals of the different hospital services should attend training courses that foster a culture where each group feels that its role in the donation process is important, creating enthusiasm and motivation to increase the rates of transplantation.

The mortality from labour accidents was a significant predictor of becoming an effective donor. The main cause of death in effective donors was cranioencephalic trauma, whereas in potential donors it was CVA. This explains the difference in the age and sex profiles between effective and potential donors; the victims of trauma were, on average, younger than patients with the diagnosis of CVA, and head trauma was much more common in males than in females; moreover, haemorrhagic stroke was equally frequent in both sexes.

As a retrospective study, the establishment of cause–effect relationship is limited. The non-validation through a review of clinical files may be considered another limitation.¹⁸ However, the comprehensive review of the individual clinical registries requires a consistent patient documentation, a reliable review protocol and a high consumption of resources.^{10,11} At national level, it would be an insurmountable task. The audit of cases of brain death in ICUs are conditioned by the policies of admission and may not reflect the true incidence of potential donors.¹⁹

The international comparability of the studies is limited by the non-uniformity of classification criteria of hospital deaths, the contraindications for donation and the definition of donor.¹¹ We used the criteria recommended by the Council of Europe and adopted by ASST.

The high correlation between the national mortality rates of CVA among people aged <65 years and donation rates¹³ may explain why we found a large pool of potential donors and a low-conversion rate.

Worldwide there has been a change in the demographics of organ donors with a growing percentage of non-traumatic deaths as traffic and labour accidents decrease.¹⁰ This new paradigm should induce the health-care organizations to recognize the individuals with brain death resulting from non-traumatic disease as potential donors. This issue is critical to improve organ donation rates in all countries, mostly in Portugal, where the rate of mortality from CVA for people of both sexes aged 25–64 years is about twice the EU 27 average.²⁰

‘Old-for-old’ deceased transplantation has been argued as an alternative to increase the supply of organs.²¹ Due to socio-demographic changes, the average age of incident patients with CKD stage 5 is 65

years.²² implying that the use of organs from victims of non-traumatic illnesses will be common practice rather than an alternative strategy.

The benefits achieved by patients submitted to kidney transplantation exceed those for patients on dialysis.^{23–25} Health authorities should consider organ donation as a priority area of health care, providing financial sustainability to hospitals with donation programmes. The accountability of hospitals should be assured by considering organ donation as a core activity and a measure of effectiveness of their performance.²⁶

In Portugal, considering the incidence of CKD stage 5 and annual increase of 30% of patients waiting transplantation, the supply of kidney is insufficient. Some authors argue for encouraging living donation as post-mortem organ donation will not be enough.⁷ In Portugal, legal requirements to living unrelated donor had been recently introduced. The option for the widespread use of living donors may raise ethical questions while the capacity of deceased donors is not exhausted.

Today, budget constraints conditioned the provision of health-care services, but as shown by several studies, the investment in organ procurement saves lives and is good value for money.^{27–31} Increasing organ availability will have a positive impact on social welfare.

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Conflicts of interest: None declared.

Key points

- This study shows that in Portugal, as in many countries, the maximum capacity for identification and recovery of organs from deceased donors has not been reached. Whereas an ethical perspective, we have the right to expand the living donor programme if the pool of deceased donors has not yet been exhausted.
- The methodology used to evaluate the availability of deceased donors on national level can be applied by authors of other countries, allowing the results to be compared.
- By the identification of factors that influence the identification and recovery of organs from deceased donors, this study contributes to the definition and implementation of strategies to increase the rates of transplantation and to guide resource allocation to programmes for organ donation.
- The criteria for assessing the performance of ICU should include the number of effective donors as a percentage of potential donors that ought to have a weight higher than other criterion, such as mortality rates.
- The performance of organ procurement organizations, measured by the rate of conversion of potential donors into effective donors, should be considered an index of quality of care provided by hospitals where there are programmes for organ donation, assessing the effectiveness of these hospitals.

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