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Potential of Donation After Unexpected Circulatory Death Programs Defined by Their Demographic Characteristics

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Background. Donation after unexpected circulatory death (uDCD) donors are often suggested to increase the number of donor organs. In 2014, a uDCD protocol was implemented in three transplant centers in the Netherlands which unfortunately did not result in additional transplantations. This study was initiated to identify demographic factors influencing the potential success of uDCD programs. **Methods.** Dutch resuscitation databases covering various demographic regions were analyzed for potential donors. The databases were compared with the uDCD implementation project and successful uDCD programs in Spain, France, and Russia. **Results.** The resuscitation databases showed that 61% of all resuscitated patients were transferred to an emergency department. Age selection reduced this uDCD potential to 46% with only patients aged 18–65 years deemed eligible. Of these patients, 27% died in the emergency department. The urban region of Amsterdam showed the largest potential in absolute numbers (52 patients/y). Comparison with the uDCD implementation project showed large similarities in the percentage of potential donors; however, in absolute numbers, it showed a much smaller potential. Calculation of the potential per million persons and the extrapolation of the potential based on the international experience revealed the largest potential in urban regions. **Conclusions.** Implementation of a uDCD program should not only be based on the number of potential donors calculated from resuscitation databases. They show promising potential uDCD percentages for large rural regions and small urban regions; however, actual numbers per hospital are low, leading to insufficient exposure rates. It is, therefore, recommendable to limit uDCD programs to large urban regions.

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The shortage of good-quality donor organs for transplantation has remained a persisting problem over the past decades. Mortality rates on the waiting list are high, and the search for new sources of transplantable organs is not a luxury but sheer necessity.

Donation after circulatory death donors (DCD) and expanded criteria donors are examples of donor sources more rigorously explored to meet the current demand for organs. The growing interest in DCD donation is illustrated by the impressive increase in numbers of global use of DCD donors

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TABLE 1.
The Maastricht categories of DCD

Category	Definition	Type
DCD 1	Donation after death in the out-of-hospital setting	Uncontrolled
DCD 2	Donation following unsuccessful resuscitation	Uncontrolled
	Out of hospital	
	In hospital	
DCD 3	Donation after awaiting circulatory arrest	Controlled
DCD 4	Donation after circulatory arrest while brain dead	Controlled
DCD 5	Donation following euthanasia	Controlled

DCD, donation after circulatory death.

from only 118 in 2000 to 2115 in 2010 and even 8708 in 2018.¹ However, the large-scale utilization of these donors in Europe has been limited to a small number of countries such as Spain, France, the United Kingdom, Belgium, and the Netherlands.² Table 1 shows the definitions of the different categories within DCD donation.

In 2016, 1284 Maastricht category 3 DCD donors were reported in Europe versus 262 Maastricht category 1 and 2 DCD donors.² In the Netherlands, almost all DCD donors have been Maastricht category 3 DCD donors. To further expand the DCD donor pool and include the Maastricht category 2 DCD donors, we performed an implementation pilot for donation after unexpected circulatory death (uDCD) in

the emergency departments (EDS) of 3 transplant centers in the Netherlands between October 2014 and April 2016.³

Despite all efforts, the implementation of a uDCD protocol did not lead to additional transplantations in these regions. Apart from legal and ethical considerations, it was postulated that demographical characteristics of the donor regions involved in this uDCD pilot program contributed to the failure to increase the donor pool.

As a result, this study was initiated to investigate the potential of uDCD in regions with different demographic characteristics in the Netherlands and compare this potential with known successful uDCD programs in France, Russia, and Spain.

MATERIALS AND METHODS

In the Netherlands, emergency services, such as ambulance services, fire brigades, and police, are divided into 25 so-called safety regions. To evaluate the impact of geographical differences and population density on the number of potential donors in the Netherlands, we used information retrieved from 2 resuscitation databases that contained information from out-of-hospital cardiac arrest (OHCA) situations until arrival at the ED from 5 of these safety regions. In addition, all available information from the previous uDCD pilot study was used, which contained data from the ED until donor recognition and eventually transplantation.³ Figure 1 illustrates the distribution of the

- 1 Groningen
- 5 Twente
- 8 Gelderland-Zuid
- 9 Utrecht
- 12 Kennemerland
- 13 Amsterdam-Amstelland
- 24 Zuid-Limburg

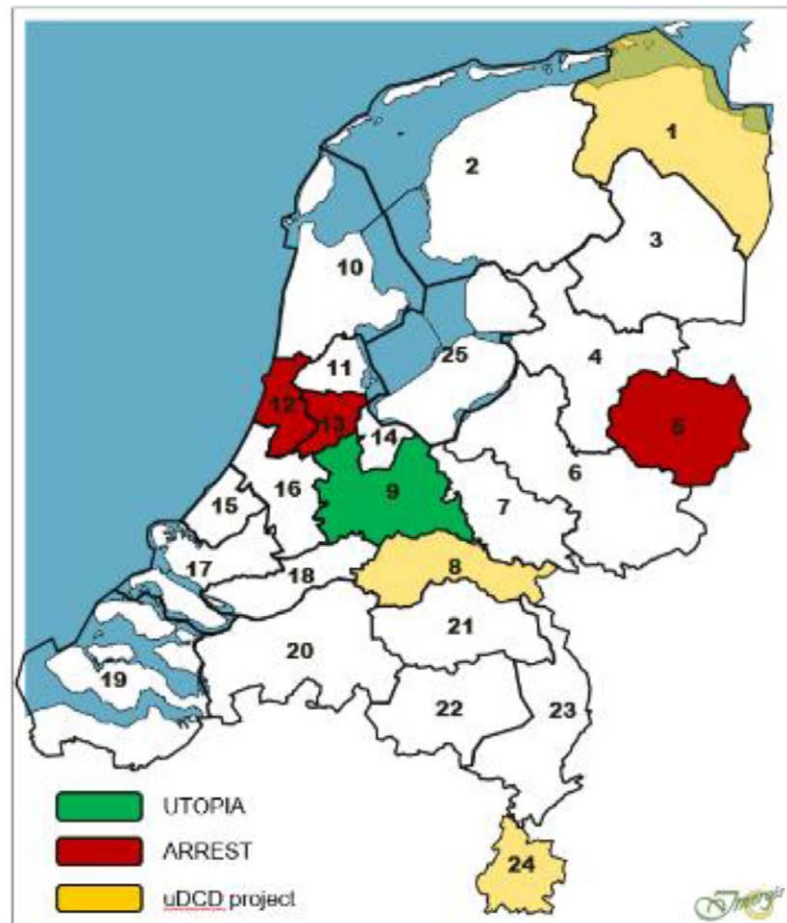


FIGURE 1. The safety regions analyzed and their distribution in the Netherlands. ARREST, Amsterdam Resuscitation Study; uDCD, donation after unexpected circulatory death; UTOPIA, Utrecht Study Group for Optimal Registry of Cardiac Arrest.

participating regions in the Netherlands. Data from 3 successful foreign uDCD programs were used for comparison. This study was exempt from approval from an ethics board.

Resuscitation Databases

The Amsterdam Resuscitation Study (ARREST),^{4,6} is a prospective observational registry of all the OHCA covering the Dutch safety regions Amsterdam, Kennemerland, North Holland North, and Twente (Figure 1). Available data from 2009 to 2014 were used in this analysis.

The Utrecht Study Group for Optimal Registry of Cardiac Arrest (UTOPIA) is a collaboration between the University Medical Center Utrecht and the safety region Utrecht to register all resuscitations within the safety region Utrecht, the Netherlands.⁷ A period of 2 y was selected for this study ranging from 2013 to 2014.

Data were extracted from the databases to gain insight into the potential number of uDCD donors. The variables included patient age, witnessed arrest, whether resuscitation was started, transport to the ED, survival, and when the patient died, the location of death. Detailed geographical characteristics of the participating control centers are given in Table 2. A population density of <500 inhabitants/km² was considered rural, between 500 and 3000 inhabitants/km² was considered suburban, and >3000 inhabitants/km² was considered urban.

uDCD Pilot in Groningen, Nijmegen, and Maastricht, the Netherlands

In the period October 2014–April 2016, a uDCD protocol was implemented at the EDs of the University Medical Center Groningen (safety region Groningen), Radboud University Medical Center in Nijmegen (safety region Gelderland-Zuid), and Maastricht University Medical Center (safety region Zuid-Limburg).³

Data of OHCA cases transferred to the EDs were collected, including age, survival, and if deceased, location of death (Table 3). For those patients who died at the ED within the agreed age criteria of the project, data were analyzed if a witnessed arrest had occurred.

Successful International uDCD Programs in Barcelona, Paris, and St Petersburg

Retrospective data were collected on potential and actual uDCD donors registered from successful uDCD programs at L'Hospital Clínic de Barcelona, Spain; the Groupe Hospitalier Pitié-Salpêtrière and the St. Louis hospital at Paris, France; and the Organ Procurement Center at St Petersburg, Russia.⁸ The demographic details of these cities are shown in Table 4. Data were collected on the donation numbers of these cities and compared to their annual national data reported by the Organización Nacional de Trasplantes in Spain and the Agence de la Biomédecine in France.^{9,10}

Construction of a Compilation Scheme

By compiling the information from these partly overlapping information sources, we have extrapolated the potential implications for organ donation from uDCD donors for different regions with various demographic characteristics in the Netherlands (Figure 2).

Inclusion and Exclusion Criteria

All available data relevant for enabling transplantation were evaluated according to the different stages illustrated in Figure 3 resulting in the number of patients eligible as uDCD donors. Three main inclusion criteria for determining the potential of OHCA patients were age between 18 and 65 years, deceased at the ED, and witnessed cardiac arrest.

To further dissect the potential for uDCD donation, we looked at the OHCA patients using the ARREST and UTOPIA databases to calculate the relative number of patients per million population and estimated the transplant potential based on the data provided by the Barcelona and Paris experience, which use comparable inclusion criteria (Table 5).

Statistics

Median and the 25th and 75th percentiles were used to describe age distribution of OHCA patients in the different study areas within the ARREST and UTOPIA database. Statistical analyses were performed with use of IBM SPSS statistics software version 24.

TABLE 2.

Characteristics of the OHCA regions and patients' characteristics with potential as DCD 2 donors

Region	Amsterdam	Kennemerland	Utrecht	North Holland North	Twente	Total
Classification	Urban	Suburban	Suburban	Rural	Rural	
Population	810 937	552 200	1 220 000	646 000	620 000	3 849 137
Area (km ²)	219	419	1385	1421	1632	5076
Pop density per km ²	3703	1318	881	455	380	758
OHCA reported	725	255	605	403	264	2252
Age (range)	66 (54–78)	69 (58–79)	69 (57–78)	67(56–77)	68(57–77)	
Resuscitation started (%) ^a	591 (82%)	228 (89%)	490 (81%)	308 (76%)	233 (88%)	1850 (82%)
Transferred to ED (%) ^b	367 (62%)	154 (68%)	298 (61%)	171 (56%)	141 (61%)	1131 (61%)
Within age criterium (%) ^c	178 (49%)	67 (44%)	127 (43%)	80 (47%)	65 (46%)	517 (46%)
Discharged alive (%) ^d	64 (36%)	28 (42%)	57 (45%)	39 (49%)	30 (46%)	218 (42%)
Deceased at ward (%) ^d	45 (25%)	14 (21%)	26 (20%)	20 (25%)	16 (25%)	121 (23%)
Unknown (%) ^d	17 (10%)	2 (3%)	13 (10%)	1 (1%)	5 (8%)	38 (7%)
Deceased at ED (%) ^d	52 (29%)	23 (34%)	31 (24%)	20 (25%)	14 (22%)	140 (27%)
Witnessed arrest (%) ^d	40 (22%)	15 (22%)	21 (17%)	17 (21%)	11 (17%)	104 (20%)

^aPercentage of started resuscitations related to OHCA reported.

^bPercentage of transferred patients to ED related to started resuscitations.

^cPercentage of patients within age criterium related to transferred patients to ED.

^dPercentage of patients related to transferred patients within age criterium.

ED, emergency department; DCD, donation after circulatory death; OHCA, out-of-hospital cardiac arrest.

TABLE 3.
Patient potential as DCD 2 donors in the project EDs

Region	Nijmegen	Groningen	Maastricht
Transferred to ED	141	149	79
Within age criteria (%) ^a	63 (45%)	78 (52%)	51 (65%)
Discharged alive (%) ^b	31 (49%)	38 (49%)	21 (41%)
Deceased at ward (%) ^b	7 (11%)	22 (28%)	14 (27%)
Deceased at ED (%) ^b	25 (40%)	18 (23%)	16 (31%)
Witnessed arrest (%) ^b	17 (27%)	14 (18%)	15 (29%)

^aPercentage of patients within age criterium related to transferred patients to ED.

^bPercentage of patients related to transferred patients within age criterium.

DCD, donation after circulatory death; ED, emergency department.

TABLE 4.
Demographic characteristics of the uDCD programs in Barcelona, Paris, and St Petersburg

	Barcelona, Spain	Paris, France	St Petersburg, Russia
Area (km ²)	101	105	1439
Number of inhabitants	1 609 000	2 244 000	4 991 000
Population density (N/km ²)	15 931	21 371	3 468
Type	Urban	Urban	Urban

uDCD, donation after unexpected circulatory death.

RESULTS

Out-of-Hospital Cardiac Arrest Within ARREST and UTOPIA

In Table 2, detailed geographical and patient characteristics are given. A clear difference in population density between the urban region of Amsterdam and rural region of Twente was found, ranging from 3703 to 380 inhabitants/km², respectively. On average, a total of 2252 OHCA cases per year were reported within the 5 regions covered by the ARREST and UTOPIA databases. Median age of the reported OHCA cases ranged from 66 to 69 y in these regions. In all regions, resuscitation was started in most cases, ranging from 76% to 89%.

Potential of uDCD at ED

In total, 1131 patients in the Dutch regions were transferred to the ED while cardiopulmonary resuscitation was ongoing, with 517 patients within the agreed age criteria. Of these 517 OHCA patients, 140 died in the ED and can be considered as potential uDCD donors. Witnessed arrest was reported in 104 of these 140 patients, which was a requirement according to the national protocol (Table 2).

In absolute numbers, the differences between the regions were found to be considerable, with urban Amsterdam having a potential of 52 uDCD donors per year; 23 and 31 uDCD donors in the suburban regions Kennemerland and Utrecht, respectively; and 20 and 14 in the rural regions North Holland North and Twente, respectively. Although the absolute numbers show a big difference, the relative numbers of patients presented at the ED after OHCA within the agreed age criteria are comparable between the urban (29%), suburban (24%–34%), and rural regions (22%–25%) (Table 2).

When considering the prerequisite of a witnessed arrest, the potential decreases further to 22% in the urban, 17%–22% in suburban, and 17%–21% in rural regions (Table 2).

Potential and Actual Results of uDCD at the ED Within Groningen, Nijmegen, and Maastricht

In the participating University Medical Centers of Groningen, Nijmegen, and Maastricht, 18, 25, and 16 patients, respectively, died on average per year within the agreed age criteria at the ED (Table 3). When comparing the number of deaths at the ED with the number of patients that presented at the ED after OHCA (both within the age criteria), this amounts to a donor potential of 23%, 40%, and 31%, respectively. These figures are similar to the relative numbers found in the ARREST and UTOPIA databases. When considering the requirement of a witnessed arrest, the potential decreased to 14 (18%) in Groningen, 17 (27%) in Nijmegen, and 15 (29%) in Maastricht.

Potential and Actual Donor Numbers in Successful uDCD Programs

L'Hospital Clínic de Barcelona reported in the period 2013 to 2016 that 52 donors were included in the uDCD donation program, of which 39 were utilized for transplantation. This implies

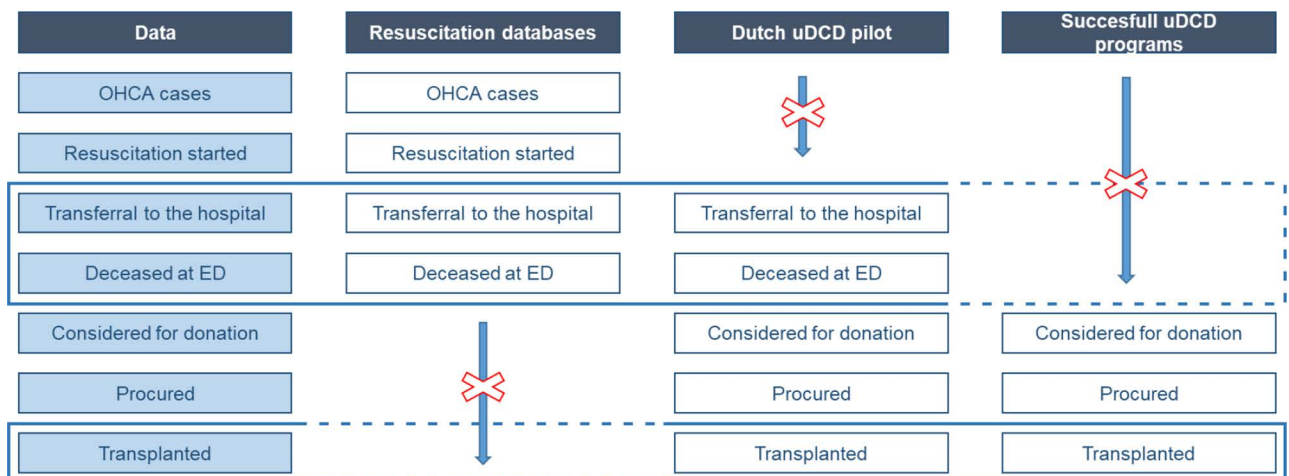


FIGURE 2. Overview of the representation of data of different steps from OHCA to transplantation by the study sources used. ED, emergency department; OHCA, out-of-hospital cardiac arrest; uDCD, donation after unexpected circulatory death.

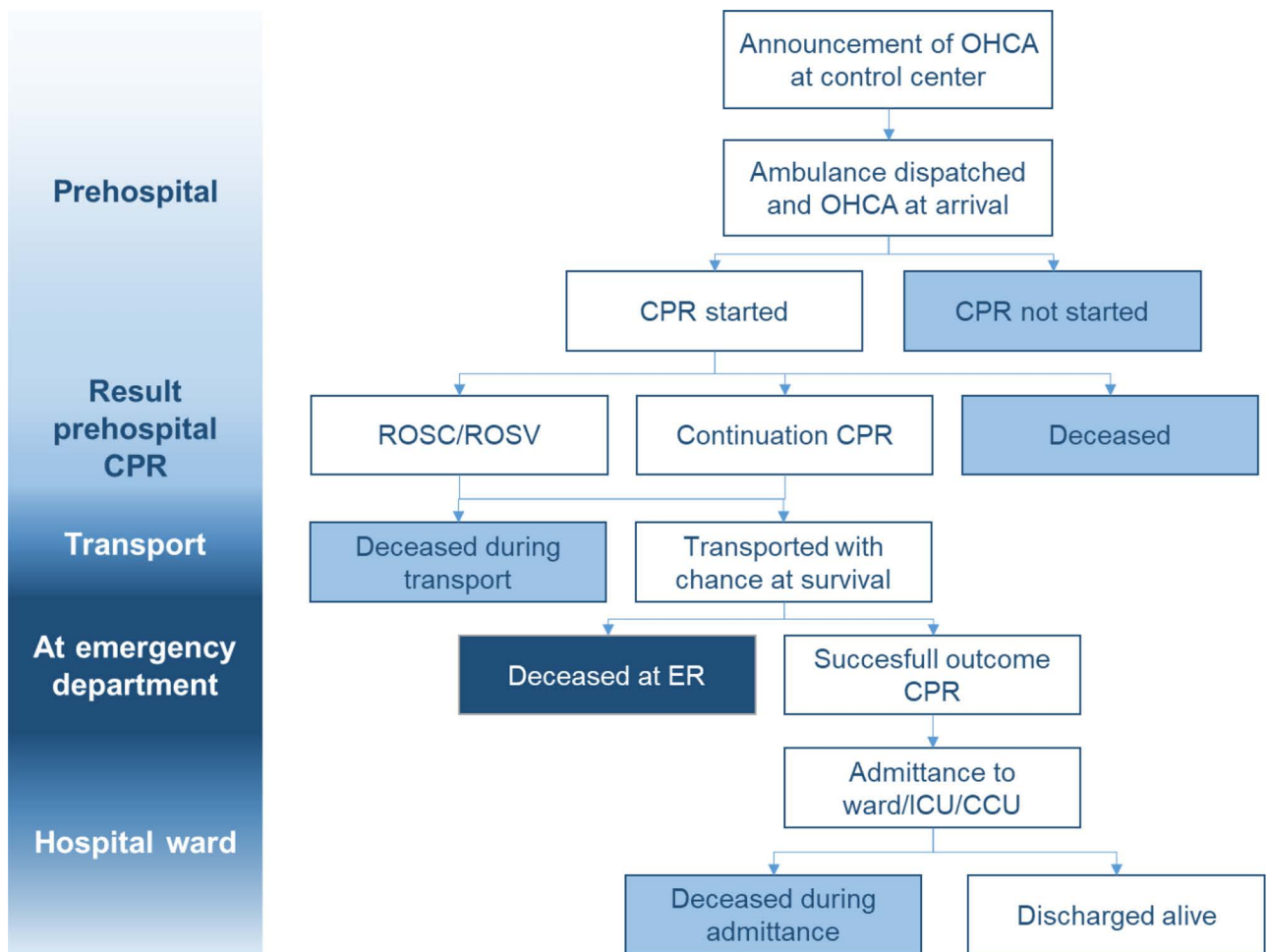


FIGURE 3. Flowchart of the steps following announcement of OHCA at the control center leading to potential uDCD donation. The dark blue box represents the patients who died in the emergency department, the so-called true potential. The patients who died before arrival at the hospital (light blue) could be potential uDCD when transferred to the hospital, and the patients who died after being admitted to the hospital are outside the scope of uDCD donation but could potentially be either donation after brain death or DCD donors. CCU, cardiac care unit; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation; ROSV, return of spontaneous ventilation; uDCD, donation after unexpected circulatory death.

TABLE 5.
Inclusion criteria within actual uDCD programs

	The Netherlands	Barcelona, Spain	Paris, France	St Petersburg, Russia
Age	Kidneys, 18–50 Lungs, 18–65	1–60	18–55	18–45
No-flow period (min) ^a	20	15–20	30	Not applicable ^b
Warm ischemia time (min) ^c	Kidney, 120 Lungs, 180	150	150	Unknown

^aTime between witnessed cardiac arrest and starting CPR.
^bCPR is not started to its full extent, only a few chest compressions to disperse administered heparin.
^cTime between cardiac arrest and start of in situ preservation.
 CPR, cardiopulmonary resuscitation; uDCD, donation after unexpected circulatory death.

an average percentage of utilization of 75% and a number of 6 actual uDCD donors per million persons (pmp)/y with at least 1 organ transplanted. When comparing this figure to the Spanish national data, the utilization rate in the same period was 68%, of which an average of 2.0 organs was transplanted per actual donor.

Paris has 2 centers with a uDCD program. Groupe Hospitalier Pitié-Salpêtrière in Paris reported 35 actual uDCD donors in the period of 2009–2015. St. Louis hospital added

another 80 actual uDCD donors in the same period, increasing the ratio of actual uDCD donors in Paris to 7.3 pmp/y. When comparing this number to the French national data, 368 actual uDCD donors were reported in France in this period, giving an overall average of 0.8 actual donors pmp/y, of which an average of 1.4 organs were transplanted per actual donor.

The Organ Procurement Center in St Petersburg included 24 uDCD donors in the period of 2009–2010, of which 22 led to retrieval and transplantation. This gives an average percentage of utilization of 91.7% and 2.2 actual uDCD donors pmp/y. An average of 2.0 transplanted organs per utilized donor was reported. However, these were all cases of cardiac arrest that occurred within a hospital.

Compiling the Databases

To further illustrate the potential in the different OHCA database regions, the number of Dutch patients is given per million population in Table 6. Also, the estimated number of transplants, based on the numbers of the Barcelona (6 pmp) and Paris (7.5 pmp) experience resulting from a theoretical number of 7 donors per million population, are given. In this comparison, the urban Amsterdam region provides the largest potential with 64 patients pmp who died in the ED. After

TABLE 6.
Number of patients per million population

	Amsterdam	Kennemerland	Utrecht	North Holland North	Twente	Total
Classification	Urban	Suburban	Suburban	Rural	Rural	
OHCA reported pmp	894	462	496	624	426	585
Resuscitation started pmp	729	413	402	477	376	481
Transferred to ED pmp	453	279	244	265	227	294
Within age criteria pmp	219	121	104	124	105	134
Discharged alive pmp	79	51	47	60	48	57
Deceased at ward pmp	55	25	21	31	26	31
Deceased at ED pmp	64	42	25	31	23	36
Witnessed arrest pmp	49	27	17	26	18	27
Estimated transplant potential ^a	6	4	9	5	4	27
Transplant potential/100 km ²	2.59	0.92	0.62	0.33	0.27	0.53

^aTransplant potential calculated 7 donors pmp.
ED, emergency department; OHCA, out-of-hospital cardiac arrest; pmp, per million persons.

correction for witnessed arrest, this resulted in 49 patients pmp. The suburban and rural regions reported between 17 and 27 patients pmp. When calculating the potential based on the average of 7 donors pmp, the differences between regions are much smaller (between 4 and 9 pmp). However, we need to consider population densities of the urban, suburban, and rural regions because this influences the transplant potential. The transplant potentials found are 2.59 donors/100 km² in the urban region (Amsterdam), between 0.62 and 0.92 donors/100 km² in the suburban regions (Kennemerland/Utrecht), and only 0.27–0.33 donors/100 km² in the rural regions (North Holland North/Twente).

DISCUSSION

This article describes possible geographical constraints and opportunities that will come to light when implementing a uDCD program, focusing on different regions with various demographical characteristics in the Netherlands. Our study was triggered by the uDCD project executed by the University Hospitals in Nijmegen, Groningen, and Maastricht that unfortunately resulted in no increase in actual donation and subsequent transplantation.³ The strict inclusion criteria of this study were named as an important possible explanation for the disappointing results because only donors aged 50 y or younger were considered eligible for kidney donation. This decision ruled out 30 donors per year who could have become potential kidney donors if a more liberal upper age limit of 65 y had been used. More recently, a few large retrospective studies have published their results and the risk factors in transplantation of uDCD kidneys, showing actually comparable results to donation after brain death donation and indicating that 60 y is probably a justifiable upper age limit, especially against the ascent of novel hypothermic or normothermic perfusion or normothermic regional perfusion.^{11,12} We, therefore, have recalculated the uDCD potential including age limits of 18–65 y.

In this study, data from different data sources to assess the potential of uDCD programs have been compiled. As displayed in Figure 3, none of the data sources provide a complete oversight from resuscitation to actual donation. However, despite this limitation, we have estimated the uDCD potential in the different safety regions to compare this to the outcome of the uDCD pilot project in the Netherlands.

The resuscitation databases ARREST and UTOPIA showed that the combined potential donor percentage of 6%—reflecting 140 patients within the agreed age criteria who died on ED of a total of 2252 patients reported as OHCA—was comparable to percentages found in the literature ranging from 0.7% to 19%.^{13–15} To be able to compare this potential of the OHCA databases with the results of the uDCD implementation study, we calculated the relative donor potential based on the actual number of patients transferred to the ED within the adjusted age criteria (18–65 y). The potential of uDCD donors (patients dying in the emergency room within the set age criteria) ranged between 22% and 34% in the OHCA databases, which are not very different from the uDCD implementation project (23%–40%).

After consultation with the leading investigators of the successful uDCD programs in Barcelona, Paris, and St Petersburg, we hypothesized that one of the main constraints might be the population density of the area covered by the ED services (the so-called safety regions). Hence, the hit change is lower in low-density areas. L'Hospital Clínic de Barcelona, as the single center in the area with a uDCD program, provides on average of 6 actual uDCD donors pmp/y. Paris gives comparable numbers with 7.3 donors pmp/y.¹⁰ Even in St Petersburg, where uDCD donors are only used when the cardiac arrest occurs in the hospital (Maastricht donation after circulatory death category 2b), 2.2 actual donors pmp/y were reported.⁸ The population density in the cities of Paris, Barcelona, and St Petersburg is much higher than that in the regions studied in this study, except for the Amsterdam region with 3479 inhabitants/km². When calculating the number of deceased donors per million inhabitants, the Amsterdam region could have a potential of 64 patients pmp (Table 6). Basing this calculation on 7 actual donors pmp in Barcelona and Paris, this would result in 6 donors per year in the Amsterdam region, which is not very different from the other regions. However, when calculating the potential per 100 km², a large difference is seen with 2.59 potential donors/km² for Amsterdam and 0.27 for the most rural regions in Twente (Table 6). As depicted in Table 7, the safety regions in the Netherlands differ in the number of inhabitants and area covered. We calculated for every region the donor potential based on the number of inhabitant, the average number of 7 donors pmp/y in Barcelona and Paris, and the donor potential per 100 km². With the estimated donor potential of 7 pmp, the donor potential of uDCD in the

TABLE 7.**Donor potential per region**

Region (number on the map)	Inhabitants	Area (km ²)	Population density (people/km ²)	Donor potential (donors/pmp)	Donor potential (donors/pmp/km ²)
Amsterdam (13)	981 095	282	3479	7	2.4
Haaglanden (15)	1 036 580	404	2566	7	1.8
Rotterdam-Rijnmond (17)	1 267 100	863	1468	9	1.0
Gooi en Vechtstreek (14)	245 090	176	1393	2	1.0
Kennemerland (12)	527 180	419	1258	4	0.9
Limburg Zuid (24)	605 795	632	959	4	0.7
Zaanstreek (11)	325 320	348	935	2	0.7
Hollands Midden (16)	769 800	831	926	5	0.6
Utrecht (9)	1 268 489	1385	916	9	0.6
Zuid-Holland-Zuid (18)	483 195	720	671	3	0.5
Gelderland Midden (7)	665 240	1181	563	5	0.4
Brabant Zuid-Oost (22)	748 300	1440	520	5	0.4
Midden-West Brabant (20)	1 100 840	2123	519	8	0.4
Gelderland Zuid (8)	538 250	1039	518	4	0.4
Noord Holland Noord (10)	636 520	1354	470	4	0.3
Brabant Noord (21)	621 357	1356	458	4	0.3
Twente (5)	626 600	1630	384	4	0.3
Limburg Noord (23)	515 520	1522	339	4	0.2
Ijsselland (4)	512 520	1695	302	4	0.2
Noord en Oost-Gelderland (6)	811 880	2755	295	6	0.2
Flevoland (25)	404 783	1419	285	3	0.2
Groningen (1)	581 600	2336	249	4	0.2
Zeeland (19)	380 935	1788	213	3	0.1
Friesland (2)	646 060	3349	193	5	0.1
Drenthe (3)	489 015	2642	185	3	0.1
Netherlands	16 789 04	33 689	498	118	0.3

pmp, per million persons.

Netherlands as a country is 188 donors per year. The potential per 100 km² is much lower with 0.3 uDCD donors per km². The more densely populated areas of Amsterdam (2.4), Haaglanden (1.8), Rotterdam-Rijnmond (1.0), and Gooi en Vechtstreek (1.0) result in a considerably higher hit chance. In Figure 4, the uDCD potential is graphically depicted.

Based on the figures presented in this study, we conclude that the most successful regions to implement a uDCD donor program are in the western more urban part of the Netherlands. In this region—also known as Randstad—3 transplant centers (Amsterdam University Medical Center, Erasmus Medical Center Rotterdam, and Leiden University Medical Center) are active, ensuring the sustainability of well-trained retrieval and transplant teams. The total estimated number of uDCD donors in the Randstad region is 29, which implies that approximately a 10% increase in the number of deceased donors in the Netherlands (250 in 2019) could be feasible.¹⁶ Additionally, it may be an advantage to concentrate uDCD programs at the EDs of transplant centers to minimize the burden of the logistics. Also, costs can be reduced as professionals and equipment required are concentrated at one location. It would be interesting to be able to predict based on these data the other larger cities across Europe. However, previous studies have shown that there is a large variation in incidence, characteristics, and outcome of OHCA across Europe. Unfortunately, this makes extrapolation of these numbers combined with the variable demographic composition of different large cities difficult.^{17,18}

In the Dutch situation, the number of potential donors could increase even further when the recognition and selection of donors are performed before arrival at the ED, as recommended in the publication of Domínguez-Gil et al¹⁹ where they describe different logistics schemes and the optimization of uDCD programs. In Spain, the selection of uDCD donors starts in the prehospital setting with the transfer of all OHCA patients by AMS personnel trained in donation protocols. In the Netherlands, one-third of the OHCA patients within the agreed age criteria are declared dead outside the hospital and therefore not transferred to the ED making it impossible to consider them as a potential uDCD donors.^{11,20,21} Our present databases lack detailed information about patients who were not transferred to a hospital because of termination of resuscitation before hospital admission; therefore an estimation of this potential for the Dutch situation cannot be made.

Although we postulate in this article that uDCD programs may be more successful in highly populated areas, 2 Spanish centers (Granada and Santander) prove that with a high organization grade, it is also possible to implement uDCD donors in less-populated areas.²¹⁻²³ This was also shown by the Maastricht University Medical Center (region Zuid Limburg), which is the only Dutch center with 35-y experience in donation of uDCD kidneys, which resulted in an average of 3 uDCD kidney donors per year.

Finally, the opt-out system in Spain and the general prodonation sentiment are often presented as a major contributing factor to its success in deceased donation. The Netherlands had an opt-in donor registry with a relative high percentage



FIGURE 4. uDCD potential for all safety regions in the Netherlands. uDCD, donation after unexpected circulatory death.

of refusal of consent for donation by the next-of-kin and changed to an opt-out system in July 2020. This recent legal change in the Netherlands will hopefully increase the number of donors becoming available as suggested in the literature.²⁴

In conclusion, despite the difficult generalization of these results because of variability in OHCA incidence across Europe and difference in demographic composition of other European cities, these data do show ground for some general recommendations when setting up a uDCD program. When searching for a suitable site, one must not only take the number of inhabitants into account but also their density, as opposed to the distance from the suggested donation site. The second lesson learned is that the resuscitation databases often make an overestimation of the number of expected donors, even shown by the successful uDCD programs in Europe.

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