THE WEEKEND EFFECT: ANALYSING TEMPORAL TRENDS IN SOLID ORGAN DONATION

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Abbreviations:

NSW, New South Wales

OTDS, Organ and Tissue Donation Service

HLA, Human Leukocyte Antigens

ANZOD, Australia and New Zealand Organ Donation Registry

ARIA+, Accessibility/Remoteness Index of Australia Plus

ABS, Australian Bureau of Statistics

MVA, Motor Vehicle Accident

ABSTRACT

Background: Research suggests patients treated over weekends experience poorer outcomes. Only one US-based study explored this weekend effect in organ donation, specifically the kidney discard rate. In Australia potential donors are referred to a donation service, and donation proceeds if family consent is granted and the donor is deemed medically suitable to donate. Organ procurement occurs when utilisation is almost certain hence discard rates are much lower than in the USA. We aimed to characterise the effect of weekend referral on organ donation in Australia.

Methods: We retrospectively reviewed all New South Wales Organ and Tissue Donation Service logs from 2010-2016. Our primary outcome was progression to organ procurement, and secondary outcomes were family consent and meeting medical suitability thresholds. We used logistic regression with random effects adjusting for clustering of referral hospitals.

Results: Of 3,496 potential donors referred for consideration, 694 (20%) progressed to organ procurement. There were fewer referrals on weekends (average 415 vs. 588 for weekdays). However, donation rates were no lower for weekend compared to weekday referrals (adjusted OR 1.17; 95% CI 0.95, 1.44). Family consent (adjusted OR 1.20; 95% CI 1.00, 1.44) and medical suitability (adjusted OR 1.15; 95% CI 0.96, 1.38) were not lower for weekend compared to weekday referrals. Similar results were found for all sensitivity analyses conducted.

Conclusions: In Australia, the donation pathway operates consistently throughout the week, with donation no less likely to proceed on weekends and holidays. This finding contrasts with findings in the USA.

INTRODUCTION

There has been much media and political attention given to hospital care over weekends, most notably in the UK (1). Research has inconsistently reported increased mortality and poorer outcomes in hospital patients admitted or treated over the weekend for a variety of emergency conditions such as stroke or myocardial infarction (2-11). However, previous analyses have found no evidence of a weekend effect on solid organ transplant outcomes (12-15), although these studies only explored recipient and organ outcomes without consideration of donor selection.

In New South Wales (NSW) potential donors are identified in acute care settings such as intensive care units and emergency departments, , usually by dedicated staff, and referred to the Organ and Tissue Donation Service (OTDS). The OTDS record details of the potential donor. The medical suitability for donation is appraised based on available information, if necessary with input from a medical team with special interest in donation. In tandem with this, for a donation to proceed the donor's next-of-kin must provide consent. Assessing medically suitability and obtaining consent often occur simultaneously, however if a donor is deemed not medically suitable soon after referral, family consent may not be sought. Referrals that achieve family consent and are deemed medically suitable become intended donors, and have their blood sent for infection screening and human leukocyte antigens (HLA) matching. If no preclusions are found the organ procurement procedure will commence and the referral becomes an actual donor. There may be variable lag time between referral and death in the potential donor, and a weekend effect could impact at any stage of this pathway.

Recent studies have found that weekend transplant surgeries involve better quality organs with shorter ischaemia times, indirectly implying that transplantable organs may be more highly selected on weekends (13, 16). There was also evidence that the procurement rate of deceased donor kidneys in the USA declined over the weekend, while the discard rate of procured kidneys increased (16). It is not clear whether this effect might be observed in other countries, although organ procurement processes do differ. For example, in Australia organ procurement usually proceeds once donation has been confirmed and a recipient has been selected. Consequently, the rate of organ discard is much lower than some jurisdictions because an organ will only be discarded if a previously unknown issue is identified during or after procurement. In 2015 the discard rate averaged across all organs in Australia was only 4.5% (17), whereas in the US it was 14% (18), and in the UK it was 15.5% (19). We aimed to quantify any association between day-of-the-week a donation referral was made and donation referral outcomes. Further, we aimed to identify at which stage of the donation referral pathway, if any, such associations existed.

METHODS

Study design and participants

We were interested to know whether the day-of-the-week referral as a potential donor was made could impact on the donation pathway. We conducted a retrospective observational cohort study using data from the Organ and Tissue Donation Service (OTDS) referral logs from 2010 to 2016. We collected data for all referrals for solid organ donation, excluding those intended only for tissue donation. We used the Australia and New Zealand Organ Donation Registry (ANZOD) definitions of intended donor (a referral who had consent obtained and blood sent for infection screening and HLA matching) and actual donor (a referral that reached at least the commencement of the organ procurement surgical procedure) (20). We also obtained discard rate data for 2010-2015. We obtained approval for this study from the University of Sydney Human Research Ethics Committee, and adhered to the Helsinki Declaration (21).

For our analysis, we excluded referred donors who eventually recovered (did not die), those who had previously registered their refusal to donate, and those where the coroner forbade donation. We also excluded potential donors with incomplete records for any of the pre-specified covariates (age, sex, cause of death, remoteness of referring location, and year of referral).

Referral characteristics

We considered characteristics potentially associated with referral outcomes at the system-level, hospital-level, and individual-level. System-level characteristics were year of referral, and number of concurrent referrals each day. The only hospital-level characteristic was the remoteness of the referring hospital, however we included random effects in our analysis to adjust for unobserved hospital-level characteristics. We used the postcode of each hospital to determine remoteness, classified according the Accessibility/Remoteness Index of Australia Plus 2011 (ARIA+) published by the Australian Bureau of Statistics (ABS) and dichotomised these as either being in a major city or regional. Individual-level characteristics were age, sex, cause of death, duration of hospital stay, comorbidities (cancers, infections, blood-borne viruses, cardiovascular diseases, respiratory diseases, diabetes, chronic kidney disease, chronic liver disease, acute organ dysfunction, connective tissue disease, peptic ulcer, hypertension, hyperlipidaemia, dementia), and high-risk behaviours (smoking status, frequent alcohol use, IV drug use, non-IV drug use, high risk partner, incarceration, men having sex with men).We did not include mode of donation (i.e. brain death or circulatory death) as referrals are often identified early in the donation pathway when it is unclear which mode of death will occur.

We calculated duration of hospital stay based on the date of admission. We were unable to include ethnicity and religion in our analysis, as prior to 2014 these were not routinely collected unless a referral proceeded to intended or actual donation. Similarly, height and weight were not routinely collected at referral and hence we were unable to consider body mass index (BMI) in our analysis.

Outcomes

Our primary outcome was actual donation, and our secondary outcomes were achieving family consent and being deemed medically suitable for donation.

Statistical Analysis

Statistical analysis was performed using Stata 14 (StataCorp 2015, College Station, TX). We conducted unadjusted analyses, comparing weekends to weekdays using Poisson regression for number of referrals, and a logistic regression for each outcome. For all models, a random effect accounted for clustering of referrals by hospitals.

For each outcome, we also fitted multivariable logistic regressions to calculate the adjusted odds ratio (OR) for weekend compared to weekday referrals. For these models, we always included age, sex, cause of death, remoteness, and year of referral. We initially included other characteristics if their univariable regression model had $p < 0.25$ and used backwards eliminations to exclude characteristics that were not confounders (largest difference in OR for weekend greater than 10%) or were not associated with actual donation ($p < 0.05$). We repeated this process for secondary outcomes (family consent and medical suitability) and included characteristics in adjusted analyses if they remained in any of the three models.

To ensure our findings were robust, we conducted a series of sensitivity analyses:

1. We considered the potential donor's day of death, rather than their day of referral.
2. We considered eight alternative definitions of weekend: Friday/Saturday, Saturday/Sunday/Public holiday, Public holiday, Sunday, Sunday/Public holiday, Friday/Saturday/Sunday, Saturday/Sunday with a public holiday before or after (long weekend), and days immediately before 1, 2, and 3+ consecutive days of weekend/public holidays (e.g. the Thursday before the Easter long weekend).
3. We separated the secondary outcome family consent into two outcomes; seeking consent and obtaining consent.

We also considered the possibility of a weekend effect in terms of the number referrals to the OTDS. We did not have access to death records for NSW for this analysis, and hence weren't able to compare referrals to all-cause mortality by day-of-the-week, nor to the most common causes of death in actual donors such as cardiovascular disease or stroke. However, data for motor vehicle accident (MVA) deaths in Australia are available through the Australian Department of Infrastructure, Regional Development and Cities Australian Road Deaths Database (22), and hence this was the best available comparator. The OTDS recorded details of the cause of death until March 2016 (with approximately 50% completeness), after which cause of death was coded in such a way that MVA deaths could not be identified. Therefore, we considered MVA deaths in NSW from January 2010 to March 2016 using chi-squared tests to obtain p-values comparing the proportion of referrals by day-of-the-week as well as by weekday vs. weekend.

RESULTS

Analysis cohort

The referred donors included in our analysis and their progression through the donation pathway are presented in Figure 1. There were 3,824 referrals for solid organ donation in NSW between 1st January 2010 and 31st December 2016, and of these 3,406 (89%) were included in our analysis cohort (Figure 1).

Among 3,406 potential donors, 694 (18%) became actual donors. All potential donors were initially assessed for medical suitability to donate and 1,397 (41%) were medically suitable. Family members consented to donation for 1,104 (32%) referrals. However, family consent was only sought for 1,787 referrals, and hence among those for whom consent was sought, 62% consented.

There were 540 actual donors from 2010-2015 for whom outcomes of retrieved organs could be determined. Of these, 39 (7%) had at least one retrieved organ discarded, while 5 (<1%) had all retrieved organs discarded. Discard rates for individual organs were 30/959 (3%) for kidneys, 15/385 (4%) for liver, 4/221 (2%) for lungs, 8/108 (7%) for heart, and 5/77 (6%) for pancreas. Of the 1,688 organs transplanted, 1,342 (80%) recipients were NSW residents. The discard rates were similar for weekday and weekend referrals, however there were too few discarded organs to perform any meaningful analysis (Supplementary Table 1). The baseline characteristics of the potential donors, and for each stage of the donation process are presented in Table 1, while the reasons for being considered not medically suitable for donation are presented in Supplementary Table 2. Younger potential donors who died from neurological conditions and trauma were more likely to become actual donors, and the most common reason for being deemed medically unsuitable for donation was when circulatory death was unlikely within 90 minutes.

Effect of day-of-the-week on referral progression

Overall, there were fewer referrals on weekends compared to weekdays ($p<0.001$, Supplementary Figure 1). The number of potential donors achieving each outcome by day-of-the-week and weekday vs. weekend is presented in Supplementary Table 3, and results of the univariable analyses are presented in Supplementary Table 4. Supplementary Figure 2 shows the unadjusted proportions of potential donors that progressed to each stage of the donation referral pathway. Compared to weekdays, more potential donors were deemed medically suitable on weekends (45% vs. 40%; $p=0.009$) and more achieved family consent (37% vs. 31%; $p=0.006$). Overall, the proportion of referrals being both medically suitable and having a consenting family on weekends was higher than weekdays (25% vs. 21%; $p=0.01$) and a higher proportion became actual donors on weekends (24% vs. 19%; $p=0.01$). The difference between the proportion of potential donors reaching each stage of the donation pathway on weekends compared to weekdays is consistent at every stage of the donation pathway, suggesting that any weekend effect, if it exists, may be occurring earlier in the donation referral process.

Results for all characteristics included in the multivariable analyses by day of referral are presented in Supplementary Table 5, while results for the multivariable analyses by day of death are presented in Supplementary Table 6. Figure 4 shows both the unadjusted and adjusted odds ratios for the three main outcomes by day of referral, as well as by day of death. Adjusted results were adjusted for age, sex, cause of death, remoteness, and year of referral. There were no observed associations for other characteristics. For all three outcomes, the adjusted ORs are greater than one, where OR>1 indicates the outcome is more likely to occur on the weekend compared to weekdays, with the lower limit of the confidence interval (CI) being slightly above one or slightly below one. Thus, we conclude that potential donors were no less likely to become actual donors on weekends compared to weekdays (OR 1.17; 95% CI 0.95, 1.44; p=0.1), nor less likely be deemed medically suitable (OR 1.15; 95% CI 0.96-1.38; p=0.1); in fact, perhaps more likely. We found evidence that family consent was more likely on weekends (OR 1.20; 95% CI 1.00, 1.44; p=0.05), but the lower CI limit remains close to one, so this result is interpreted with caution.

Sensitivity analyses

Our sensitivity analyses using day of death for potential donors, instead of day of referral, showed that all three outcomes are more likely (P<0.05) on weekends, with odds ratios slightly higher compared to using day of referral (especially for family consent). Nevertheless, the lower limits of the CIs remain close to one for both actual donation and medical suitability, and so we conclude these results do not qualitatively differ from day of referral. We also found that using different definitions of weekend did not qualitatively change these results (see Supplementary Table 7). The odds ratio of a referral becoming an actual donor on a weekend compared to a weekday ranged from 0.98 (weekend defined as Friday and Saturday) to 1.56 (weekend defined including a public holiday or a long weekend). However, many of the definitions considered overlap with one another, and hence results must be interpreted with caution in the context of multiple comparisons (which increases the chance of spurious associations).

In our sensitivity analysis separating the secondary outcome of family consent into seeking consent and obtaining consent, family consent was more likely to be sought on weekends (OR 1.25; 95% CI 1.04, 1.49; p=0.02), but when consent was sought, consent was no less likely on weekends (OR 1.08; 95% CI 0.85, 1.36; p=0.5) (see Supplementary Table 8).

The results of our analysis comparing referrals and deaths in NSW resulting from motor vehicle accidents are summarised in Supplementary Figure 3. Although MVA deaths were less likely to be referred for donation on weekends compared to weekdays, this difference was not significant (3.5% vs. 4.6%, p=0.2).

DISCUSSION

We conducted an observational cohort study of all organ donor referrals made in NSW between 2010 and 2016. We found that donor referrals were no less likely to progress to actual donation on weekends compared to weekdays, and possibly slightly more likely (based on the direction of the ORs). Any increase in actual donation appears to be driven more from a higher likelihood of family consent over the weekend, and not due to medical suitability. Our findings were robust to multiple different definitions of weekend. Furthermore, among potential donors for whom consent was sought, consent was not more likely on weekends. This suggests that any increase in family consent is perhaps due to an increase in the proportion of families being asked for consent on weekends.

While our results differ from findings in the USA (16), there are also key differences in the analysis including the primary outcome of discard rate (compared to rate of actual donation in our study), and kidneys as the unit of analysis (compared to potential donors of any solid organs in our study). Despite this difference, given the comparative low discard rates in Australia, these differences in approach are not likely to change our interpretation that day-of-the-week does not affect donation services in Australia in the same ways as it does in the USA.

Our study relied upon an administrative dataset, and hence there were limitations in the variables available for analysis, and their completeness. It cannot be determined from the available dataset why there were fewer donor referrals on weekends, but this may be due to reduced hospital resources over the weekend, or a lower number of deaths over the weekend which are considered suitable for donation. Some decisions surrounding care may be more likely to be made during the week when services such as imaging are better staffed, which could impact the timing of referral for donation. In our sensitivity analysis of motor vehicle accidents, we found that deaths were no less likely to be referred for donation on weekends.

It is possible that a negative weekend effect due to fewer available resources is being masked by the lower number of donation referrals on weekends causing less strain on the system. Although we are not able to address this possibility directly with the available dataset, it does not detract from our conclusion that referrals are no less likely to progress to actual donation on weekends and hence that resources are being managed efficiently throughout the week.

Further research could use data on in-hospital deaths (e.g. from the NSW admitted patient data collection) to determine if there is evidence of a weekend effect at the referral stage of the donation pathway.

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DISCLOSURE

The authors declare no conflicts of interest.

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FIGURES

Figure 1: Flowchart showing donor referrals made in New South Wales 2010-2016, with exclusions from the analysis cohort
Figure 2: Odds ratios for actual donation, family consent, and medical suitability based on potential donors' day of referral and day of death

TABLES

Table 1: Baseline characteristics

Referrals, n (%)	**Population**									
	Potential donors		Medically suitable [1]		Consent sought		Consent given [2]		Actual donors	
Total	3,406	(100)	1,397	(100)	1,787	(100)	1,104	(100)	694	(100)
Age										
Mean (SD)	56.7	(19.6)	51.1	(18.9)	52.7	(19.5)	52.0	(19.1)	48.9	(18.3)
0-17	158	(5)	90	(6)	112	(6)	68	(6)	49	(7)
18-44	624	(18)	343	(25)	401	(22)	264	(24)	196	(28)
45-54	550	(16)	274	(20)	321	(18)	201	(18)	141	(20)
55-64	713	(21)	335	(24)	419	(23)	263	(24)	164	(24)
65-74	741	(22)	244	(17)	336	(19)	205	(19)	108	(16)
75+	620	(18)	111	(8)	198	(11)	103	(9)	36	(5)
Sex										
Female	1,410	(41)	625	(45)	768	(43)	478	(43)	316	(46)
Male	1,996	(59)	772	(55)	1,019	(57)	626	(57)	378	(54)
Cause of death										
Cerebral hypoxia/ischaemia	376	(11)	181	(13)	222	(12)	128	(12)	77	(11)
Intracranial haemorrhage	1,124	(33)	569	(41)	692	(39)	406	(37)	280	(40)
Non-neurological condition	1,433	(42)	396	(28)	560	(31)	364	(33)	190	(27)
Other neurological condition	19	(1)	3	(<1)	6	(<1)	4	(<1)	3	(<1)
Trauma	454	(13)	248	(18)	307	(17)	202	(18)	144	(21)
Remoteness										
Regional	346	(10)	126	(9)	185	(10)	112	(10)	57	(8)
Major city	3,060	(90)	1,271	(91)	1,602	(90)	992	(90)	637	(92)

Referrals, n (%)	Population									
	Potential donors		Medically suitable [1]		Consent sought		Consent given [2]		Actual donors	
Year of referral										
2010	299	(9)	149	(11)	163	(9)	98	(9)	86	(12)
2011	329	(10)	151	(11)	194	(11)	113	(10)	74	(11)
2012	375	(11)	169	(12)	213	(12)	144	(13)	88	(13)
2013	439	(13)	182	(13)	238	(13)	162	(15)	102	(15)
2014	499	(15)	190	(14)	265	(15)	157	(14)	92	(13)
2015	673	(20)	244	(17)	337	(19)	220	(20)	127	(18)
2016	792	(23)	312	(22)	377	(21)	210	(19)	125	(18)
Body mass index (BMI)										
Mean (SD)	27.0	(6.8)	26.5	(6.1)	26.9	(6.6)	26.8	(6.2)	26.4	(6.0)
Underweight (0-18.4)	46	(5)	33	(5)	39	(5)	34	(5)	28	(6)
Normal (18.5-24.9)	343	(37)	233	(39)	273	(37)	241	(37)	193	(39)
Overweight (25-29.9)	314	(34)	210	(35)	257	(35)	233	(35)	179	(36)
Obese (30-39.9)	178	(19)	104	(17)	140	(19)	126	(19)	83	(17)
Extremely Obese (40+)	40	(4)	22	(4)	30	(4)	26	(4)	16	(3)
Not reported	*2,485*	*(-)*	*795*	*(-)*	*1,048*	*(-)*	*444*	*(-)*	*195*	*(-)*
Religion										
Christian	1,100	(63)	518	(60)	648	(61)	453	(61)	309	(60)
Other Religion	171	(10)	87	(10)	98	(9)	38	(5)	27	(5)
No Religion	474	(27)	258	(30)	316	(30)	249	(34)	179	(35)
Not reported	*1,661*	*(-)*	*534*	*(-)*	*725*	*(-)*	*364*	*(-)*	*179*	*(-)*
Ethnicity										
White	1,693	(72)	800	(73)	1,025	(75)	805	(83)	550	(83)
Non-white	643	(28)	300	(27)	348	(25)	160	(17)	110	(17)
Not reported	*1,070*	*(-)*	*297*	*(-)*	*414*	*(-)*	*139*	*(-)*	*34*	*(-)*

Referrals, n (%)	Population									
	Potential donors		Medically suitable [1]		Consent sought		Consent given [2]		Actual donors	
Comorbidities (previous or current)										
Cancer	530	(16)	109	(8)	193	(11)	143	(13)	63	(9)
Infection	591	(17)	116	(8)	197	(11)	132	(12)	50	(7)
Blood borne virus	362	(11)	198	(14)	247	(14)	223	(20)	167	(24)
Cardiovascular disease	1,103	(32)	341	(24)	480	(27)	280	(25)	145	(21)
Respiratory disease	539	(16)	195	(14)	260	(15)	175	(16)	97	(14)
Peripheral vascular disease	202	(6)	49	(4)	85	(5)	53	(5)	17	(2)
Cerebrovascular disease	1,200	(35)	588	(42)	731	(41)	450	(41)	306	(44)
Diabetes	573	(17)	176	(13)	252	(14)	147	(13)	69	(10)
Chronic kidney disease	266	(8)	40	(3)	72	(4)	48	(4)	16	(2)
Chronic liver disease	182	(5)	36	(3)	51	(3)	37	(3)	18	(3)
Acute organ dysfunction	362	(11)	43	(3)	86	(5)	57	(5)	14	(2)
Peptic ulcer disease	40	(1)	16	(1)	22	(1)	18	(2)	10	(1)
Hypertension	1,163	(34)	436	(31)	597	(33)	370	(34)	211	(30)
Hyperlipidaemia	569	(17)	249	(18)	335	(19)	224	(20)	139	(20)
Dementia	43	(1)	10	(1)	15	(1)	9	(1)	4	(1)
Connective tissue disease	52	(2)	21	(2)	31	(2)	21	(2)	12	(2)
High risk behaviours (previous or current)										
Smoker	918	(27)	544	(39)	648	(36)	521	(47)	384	(55)
Frequent alcohol use	505	(15)	242	(17)	300	(17)	227	(21)	159	(23)
IV drug use	242	(7)	71	(5)	94	(5)	59	(5)	33	(5)
Non-IV drug use	240	(7)	142	(10)	169	(9)	145	(13)	106	(15)
High risk partner	24	(1)	17	(1)	18	(1)	16	(1)	13	(2)
Incarcerated	37	(1)	15	(1)	19	(1)	17	(2)	13	(2)
Men having sex with men	15	(<1)	7	(1)	10	(1)	8	(1)	6	(1)

Referrals, n (%)	Population									
	Potential donors		Medically suitable [1]		Consent sought		Consent given [2]		Actual donors	
Number of other referrals on same day										
No other referrals	693	(20)	293	(21)	383	(21)	249	(23)	159	(23)
1 other referral	1,024	(30)	462	(33)	575	(32)	334	(30)	216	(31)
2+ other referrals	1,689	(50)	642	(46)	829	(46)	521	(47)	319	(46)
Time from admission to referral										
Within 24 hours	2,118	(62)	800	(57)	1,056	(59)	606	(55)	348	(50)
Between 1 and 7 days	893	(26)	477	(34)	561	(31)	376	(34)	281	(40)
More than one week	395	(12)	120	(9)	170	(10)	122	(11)	65	(9)

[1] Total of 1,397 medically suitable includes medically suitable but no next of kin (n=3), medically suitable but consent not sought for unspecified reason (n=39), medically suitable but not consented (n=613), and intended donors (n=742)

[2] Total of 1,104 with consent given includes consented but not medically suitable (n=362), and intended donors (n=742)