

# Trends in Corneal Donation From 2013 to 2022 in Aotearoa-New Zealand: Impact of Donor Age, Gender, Ethnicity, and COVID-19

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**Purpose:** To evaluate corneal donation demographics in New Zealand (NZ) and explore changes over time.

**Methods:** Data were collected from all donated corneas processed by the New Zealand National Eye Bank over a 10-year period from January 2013 until December 2022. Demographic data including age, self-identified ethnicity, and gender were collected, along with location and cause of death. National death data for the corresponding period were collected online from Statistics New Zealand.

**Results:** A total of 1842 donors were processed; 1414 (76.8%) were sourced from Aotearoa-New Zealand and the remainder from Australia/United States. There was a small but statistically significant median age difference between NZ donors (68 years, interquartile range 55–76) and overseas donors [66 years (interquartile range) 51–70]. Most ( $n = 1151$  81.4%) of NZ donors died in hospital settings, with the most common cause of death being cerebrovascular ( $n = 444$  31.4%). Individuals were less likely to donate their cornea if they were female, [incidence rate ratio (IRR) 0.746,  $P < 0.001$ ] older age (IRR 0.968,  $P < 0.001$ ), or if they were of Māori (IRR 0.178,  $P < 0.001$ ) or Pasifika ethnicity (IRR 0.125,  $P < 0.001$ ). There was also a statistically significant decrease in donation rates over time (IRR 0.945,  $P < 0.001$ ).

**Conclusions:** There remains a profound gap between the demand for corneal transplantation and corneal tissue donation, which is worsening with time. Donor age, gender, and ethnicity seem to influence corneal donation rates. These demographic differences may be ameliorated by increased education, cultural safety, further research into those willing to donate, and the establishment of an organ/tissue donation registry.

**Key Words:** cornea, COVID-19, donor, Māori, Pasifika, donation (*Cornea* 2024;00:1–6)

Corneal transplantation is the end-stage management for several sight-threatening conditions and has the potential to completely restore vision. It is the most commonly performed tissue transplant in the world, excluding skin grafts. It is arguably the most successful because of the cornea's relative immune privilege resulting in low rejection rates.<sup>1</sup> In Aotearoa-New Zealand (NZ), the number of corneal transplants performed is around 6.06/100,000 population/year, a rate that has been steadily increasing over the past 2 decades.<sup>2–5</sup>

Unfortunately, it can be challenging to procure enough corneal tissue to meet the increasing demand. Corneal donation is unique compared with solid organ donation in that it does not require blood matching, but selection criteria may be more stringent.<sup>6,7</sup> Many countries struggle to find sufficient corneal donors to meet demand. Waitlist times for a corneal transplant vary widely from country to country, reported as from 2 months to longer than 2 years.<sup>8,9</sup> In NZ, Māori (the indigenous people of Aotearoa-NZ) and Pasifika (Pacific people living in Aotearoa-NZ) have a disproportionately high prevalence of keratoconus, which may require corneal transplantation.<sup>2,10</sup> However, anecdotal reports state that the number of Māori and Pasifika donors (17.2% and 8% of the NZ population, respectively) are relatively low. This study aimed to explore the characteristics of corneal donors in NZ, exploring barriers and enablers to corneal donation.

## METHODS

Data were collected on all donated corneas processed by the New Zealand National Eye Bank over 10 years from January 2013 until December 2022. Demographic data including age, ethnicity, and gender were collected. Gender and ethnicity were self-identified. Location of tissue collection and cause of death were also collected.

National data on death rates for the corresponding period (from January 2013 until December 2022) were collected online from Statistics NZ.<sup>11,12</sup> Death rates were given by month and were tabulated to calculate yearly rates by age, gender, and ethnicity.

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TABLE 1. Corneal Donor Characteristics

	New Zealand (n = 1414)	Imported (n = 428)	P
Age	Median 68 (IQR 55–76)	Median 66 (IQR 51–70)	<0.001
Male	871 (61.6%)	265 (62.2%)	0.344
Death to enucleation interval (h)	Median 12 (IQR 6–18.5)	Median 14 (IQR 8–19)	0.002
Death storage interval	Median 19.5 (IQR 12–25.5)	Median 18.5 (IQR 11–23)	0.003
Storage type			<0.001
Optisol	0 (0%)	159 (37.3%)	
Organ culture	1414 (100%)	266 (62.0%)	
Other or not recorded	0 (0%)	3 (0.7%)	

IQR, interquartile range.

This study was approved by the New Zealand Health and Disability Ethics Committee (Reference: 2024 FULL 19611) and adheres to the principles of the Declaration of Helsinki.

Data were entered into an Excel spreadsheet and analyzed in STATA version 15. The normality of distribution was assessed with the Shapiro–Wilks test. Continuous variables were reported as median (interquartile range) and categorical variables as n (%). Continuous variables were compared with the Mann–Whitney *U* test for skewed data and categorical tests with  $\chi^2$ . Rates of corneal donation were calculated by year, age, gender, and ethnicity, with deaths in these categories as the denominator. These rates were compared with Poisson regression analysis and the incidence rate ratio (IRR) was calculated. All tests were 2-tailed and a *P*-value of <0.05 was considered statistically significant.

RESULTS

Over the 10-year study period, 1842 donors were processed, with 1414 (77.3%) of them from NZ-based donors. The remaining 428 (23.2%) came from Australia (n = 375, 87.6%) and the United States (n = 53, 12.4%). A description of the characteristics of corneal donors for NZ and overseas donors is reported in Table 1. There was a small but statistically significant difference in age between the NZ and overseas donors, with the median age in NZ being 68 years, compared with 66 overseas (*P* < 0.001). No difference in gender was observed between the 2 cohorts. Death to enucleation time was marginally shorter in the NZ donors (12 vs. 14 h, *P* = 0.002), and death to storage interval was marginally longer (19.5 vs. 18.5 h, *P* = 0.003). Corneas in NZ were all stored using organ culture at 34°C, whereas 37.3% of overseas corneas used Optisol, 4°C a corneal storage medium for temporary corneal preservation<sup>13</sup> (*P* < 0.001).

Most of donors within NZ came from the Auckland region, with Auckland (a city of 1.7 million) having the highest donation rate of 5.8 per 10,000 population. However, not only large metropolitan areas exhibited high donation rates, with the second highest rate being Nelson (a city of 53,000) at 4.9 per 10,000 population. The relative rates of corneal donation by region per 10,000 population across NZ are demonstrated in Figure 1. Most donors came from public hospitals, mainly intensive care settings (as multiorgan donor

candidates) (n = 1151, 81.4%), followed by community settings (n = 82, 5.8%), coroner (n = 100, 14.4%), and hospice (n = 81, 5.7%). Of the NZ donors, 289 (19.8%) were multiorgan donors facilitated through Organ Donation New Zealand. These trends in corneal donors over time are demonstrated in Figure 2.

The most common cause of death of the NZ donors was cerebrovascular disease (n = 444, 31.4%), specifically “stroke.” However, with many donors coming from ICUs, this may be predominated by brain-dead multiorgan donor

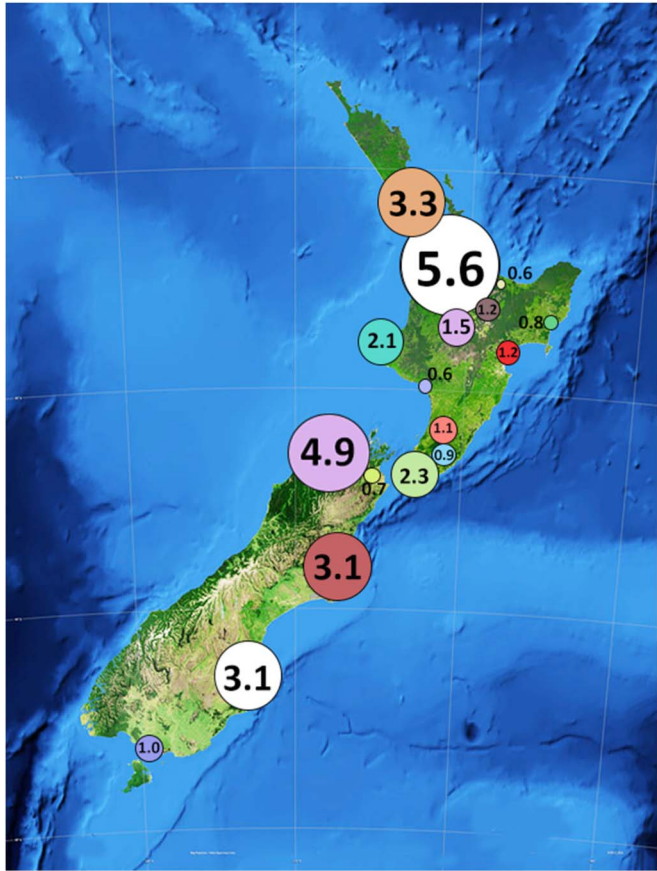
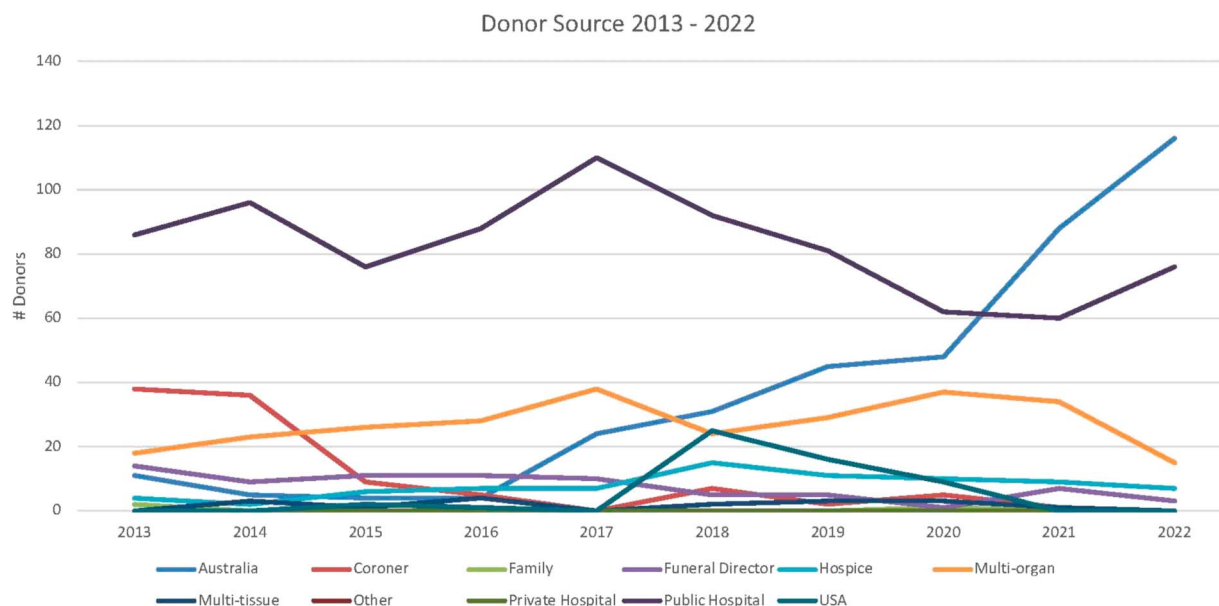


FIGURE 1. Distribution of corneal donors per 10,000 population by city/region. (The full color version of this figure is available at [www.corneajrnl.com](http://www.corneajrnl.com).)



**FIGURE 2.** Source of donors obtained by New Zealand National Eye Bank between 2013 and 2022. (The full color version of this figure is available at [www.corneajrnl.com](http://www.corneajrnl.com).)

candidates. The causes of death for the NZ donors are outlined in Table 2. Notably, “Poisoning” was used broadly to describe all cases of intentional or unintentional overdose of a nontherapeutic substance. The final total is 1413, one short of the total of 1414 as in a single case, the donor cornea was from a living participant.

Poisson regression was used to examine the rate of corneal donation compared with death rates for the groups, demonstrated in Table 3. On univariate analysis, the following were associated with lower rates of corneal donation: female gender (IRR 0.640;  $P < 0.001$ ); increasing age (IRR 0.973;  $P < 0.001$ ); Māori ethnicity (IRR 0.322;  $P < 0.001$ ); Pasifika ethnicity (IRR 0.230;  $P < 0.001$ ); and more recent year (IRR 0.945;  $P < 0.001$ ). Asian ethnicity was associated with a higher rate of corneal donation (IRR 1.282;  $P = 0.041$ ).

On multivariate analysis, the following were associated with a decreased rate of corneal donation: female gender (IRR 0.746;  $P < 0.001$ ); older age (IRR 0.968;  $P < 0.001$ ); Māori ethnicity (IRR 0.178;  $P < 0.001$ ); Pasifika ethnicity (IRR 0.125;  $P < 0.001$ ); and more recent year (IRR 0.954;  $P < 0.001$ ). Asian ethnicity and Middle Eastern, Latin American, African (MELAA) or other ethnicity was not significantly

associated with altered rates of corneal donation on multivariate analysis.

## DISCUSSION

Despite the continuing successful evolution of corneal transplantation, particularly over the last 3 decades, the disparity between corneal donation rates and demand for transplantation remains a major concern in many countries. We believe that this is the first major analysis of the demographics and trends of corneal donation within NZ, a country of 5 million inhabitants in the South Pacific. Interestingly, this study demonstrates clear demographic differences in those donating their corneas, with females, older age, Māori, and Pasifika ethnicities associated with lower corneal donation rates. Furthermore, the gap between supply and demand for tissue donation seems to be worsening, with lower donation rates year by year, despite steady population growth.

In this study, we noted that 706 (38.3%) donors were female with a gender ratio of 0.62 ( $P < 0.344$ ). Historically, the influence of gender on organ/tissue donation is a complex one. It has been well documented that living organ donors (such as kidney and liver) are far more likely to be female than male across all cultures and age ranges.<sup>14</sup> This has been attributed, by some authors, to generalizations regarding the caring or empathetic female temperament making women more willing to donate tissue or organs.<sup>14,15</sup> A study of 918 voluntary corneal donors from the Beijing Tongren National Eye Bank found a preponderance toward elderly, educated female donors.<sup>16</sup> However, a retrospective Indian study of 373 corneal donors found that there were double the amount of male donors as females.<sup>17</sup> The lower rates of female corneal donation on

**TABLE 2.** Causes of Death Within NZ Donors

Cause of Death	Number of Donors
Cerebrovascular	444 (31.4%)
Cardiovascular	272 (19.2%)
Cancer	244 (17.3%)
Multiorgan failure	199 (14.1%)
Sepsis	131 (9.3%)
Trauma	113 (8.0%)
Poisoning	10 (1%)

TABLE 3. IRR of Corneal Donation by Demographic

	Univariate	P	Multivariate	P
	IRR (95% CI)		IRR (95% CI)	
Female	0.640 (0.572–0.715)	<0.001	0.746 (0.667–0.835)	<0.001
Age	0.973 (0.971–0.975)	<0.001	0.968 (0.966–0.970)	<0.001
Ethnicity*				
Māori	0.322 (0.245–0.424)	<0.001	0.178 (0.135–0.234)	<0.001
Pasifika	0.230 (0.138–0.382)	<0.001	0.125 (0.075–0.209)	<0.001
Asian	1.282 (1.011–1.627)	0.041	0.804 (0.631–1.024)	0.078
MELAA or other	0.887 (0.502–1.566)	0.679	0.571 (0.323–1.009)	0.054
Year	0.945 (0.928–0.963)	<0.001	0.954 (0.936–0.972)	<0.001

\*White used as comparator.  
CI, confidence interval.

multivariate analysis identified in our study may typically reflect several factors that cannot be identified from our data. However, we believe that this may also result from poor communication and education around corneal donation after death. Individual preferences may not be actualized if the decision to donate is made by the spouse or children, especially if the topic of donating tissue/organs has not been broached before death. Indeed, it has been shown that a male relative is more likely to decline in favor of preserving “dignity” than a female relative whereas, women are more likely to agree to donation on behalf of deceased men.<sup>18–20</sup>

Notably, the corneal donation rates in our current NZ study decreased with increasing age (IRR 0.968;  $P < 0.001$ ); surprisingly, this runs counter to the reported altruism of the elderly, being more willing to donate organs and tissue.<sup>16,21</sup> A potential reason for this may be the preponderance of ICU-based donors, whom are on average, younger than community-based donors. Public knowledge around corneal donation is poor, even among health professionals.<sup>18,21–24</sup> Donation of tissue/organs is often perceived as only applicable in young, previously healthy individuals. A survey of 371 Australian patients found that 44% thought that corneal donation could only occur if a patient was declared “brain dead.”<sup>24</sup> In hospice settings, with older, more comorbid patients, nurses report feeling uncomfortable bringing up the topic of corneal donation, because they are unsure of the suitability of these patients for donation.<sup>25</sup> These factors may contribute to the lower rates of donation found with increasing age. Although interestingly, intention to donate and actual donation rates seem to be misaligned, with elderly people more likely to be willing to donate when questioned but less likely to actually donate based on eye bank data.<sup>16,17,22,25</sup> These confounding variables suggest systemic barriers to corneal donation in the elderly, which may include inadequate health literacy in relation to donation, dying in the community, lack of access to donation services, and poor communication among family members around individual preferences.

The ethnic differences in corneal donation rates outlined in multivariate analysis in the current study are likely multifactorial. Māori have a unique cultural perspective on

the body and consider it to be “tapu” or sacred, with many Māori preferring to have their body parts returned to them so that they can be buried as a whole.<sup>26</sup> Pasifika rates were also low, but it is difficult to ascertain the reasons behind this. Limited awareness of these cultural differences by health care professionals may act as barriers to initiating the conversation around corneal donation in these ethnic groups. In health care scenarios, the fear of causing cultural offence may supersede the deeper understanding of cultural issues required for culturally safe practice.<sup>27</sup>

The role of an individual’s relationship with health care professionals when considering tissue/organ donation cannot be understated, and there are several reasons why this relationship may not be well established for Māori and Pasifika. Both ethnic groups have well-documented poorer access to ocular care and health care in general. Māori and Pasifika are more likely to experience disease progression while on a surgical waitlist and more likely to die of surgical complications.<sup>2,10,28</sup> These inequities combined with a Western-centric model of health care equates to a more challenging clinician–patient relationship, which may lack the trust required for consent to corneal donation. There are also more likely to be language barriers, particularly among Pasifika.<sup>29</sup> Therefore, it may be challenging to convey the nuances of the corneal donation process via an interpreter. There may also be a perceived cultural preference for caring for the sick and elderly at home in these ethnic groups. As most corneal donors come from public hospitals, it can be assumed that dying in the community decreases the likelihood of becoming a corneal donor.

The decline in corneal donation rates identified in the current study over the past 3 years in the COVID-19 era is ubiquitous globally. Several international eye banks have reported a sharp decline in donation numbers during and immediately after the pandemic.<sup>30–33</sup> This is easily attributed to poor access to health care services, fear of COVID-19 transmission through graft tissue, and general breakdown of systems during the global pandemic. It is more challenging to evaluate the less marked but steady decline in corneal donation rates in NZ leading up to the pandemic. This may be a consequence of an increasingly overstretched health system with few resources for facilitating donation

conversations. There are also significantly fewer coroner cases now as opposed to the previous decade, because of a gradual policy change.<sup>34</sup> Coroners may facilitate tissue/organ donation, but over the last decade, only 14.4% of corneal donations came from this avenue in NZ. Other trends highlighted in longitudinal data include an overall decrease in donors from public hospitals and a consequent increase in donors from Australia. There is also no formal donor registry in NZ, for corneas or otherwise, and this would require government input. Individuals wishing to donate may agree to “DONOR” on their NZ Driver’s License, but this is not legally binding and next of kin consent must still be granted. Ultimately, the greatest barrier of all to donation, not only eye donation, is the lack of a systematic program or pathway for donation.

The shortage of donated corneal tissue is a worldwide problem. A global survey of corneal transplantation and eye banking estimated that the current ratio of corneas to those awaiting a corneal transplant is 1:70.<sup>35</sup> This study analyzed data from 82 countries to assess the corneal transplantation process, and interestingly, around half of these countries use an “opt-out” system, in which individuals are automatically considered donors unless they explicitly refuse. Other countries such as the United States use an “opt-in” registry as legal authorization that cannot be superseded by next-of-kin. This has been suggested as a possible solution to the low tissue/organ donation rates in NZ.<sup>34</sup> Other barriers to corneal donation identified include a lack of an eye donation registry, poor public/health professional awareness, and cultural norms.<sup>19,22,24,25</sup> Successful interventions have been trialed including educational programs for medical students,<sup>23</sup> simulations for ICU nurses,<sup>36</sup> introduction of specialist nurses trained in organ donation,<sup>37</sup> and Facebook’s introduction of the “donor” status tool that caused a 21-fold increase in tissue/organ donor registrations in the United States on the first day of launch.<sup>38</sup>

Although this study presents novel findings of the corneal donor demographics within NZ, there are several limitations. First, 23.2% of donors throughout the 10 years were obtained from Australia or the United States. The demographic data were incomplete for this group and, therefore, they were excluded from the detailed univariate and multivariate analysis of donor demographics. Australia has a profoundly different eye bank infrastructure that influences the demographics of their donors. Second, there is an established numerator–denominator bias in how ethnicity data are reported in NZ, with significantly more people self-reporting ethnicity as Māori or Pasifika on the census, as opposed to in other areas, such as when registering at the hospital.<sup>39</sup> This discrepancy likely overflows into the ethnicity data collected on corneal donation and makes mortality data particularly challenging to analyze accurately. Third, the corneal donor demographics only include corneas that were donated, there is no data on those who intended to donate, and the final decision about the donation process is usually not made by the deceased individual. As this study is retrospective, the barriers and enablers to corneal donation could not be evaluated quantitatively.

In conclusions, NZ has a profound corneal donation deficit, worsening over time and compounded by a global pandemic. The demographics of these corneal donors give new insight into the pattern of corneal donation, but further

investigation is needed to understand the underlying systemic barriers involved. Solutions that have been effective overseas include increasing education, initiating a donor registry, and novel interventions such as social media involvement. Qualitative focus group discussion around corneal donation concerns may be prudent. Ongoing study into the demographics of individuals self-identifying as “DONOR” on driver’s licenses and how corneal donation rates compared with solid organ donation rates may be beneficial.

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