

Public attitudes towards novel reproductive technologies: a citizens' jury on mitochondrial donation

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STUDY QUESTION: Does an informed group of citizens endorse the clinical use of mitochondrial donation in a country where this is not currently permitted?

SUMMARY ANSWER: After hearing balanced expert evidence and having opportunity for deliberation, a majority (11/14) of participants in a citizens' jury believed that children should be able to be born using mitochondrial donation.

WHAT IS KNOWN ALREADY: Research suggests that patients, oocyte donors and health professionals support mitochondrial donation to prevent transmission of mitochondrial disease. Less is known about public acceptability of this novel reproductive technology, especially from evidence using deliberative methods.

STUDY DESIGN, SIZE, DURATION: This study comprised a citizens' jury, an established method for determining the views of a well-informed group of community members. The jury had 14 participants, and ran over one and a half days in 2017.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Jurors were members of the public with no experience of mitochondrial disease. They heard and engaged with relevant evidence and were asked to answer the question: 'Should Australia allow children to be born following mitochondrial donation?'

MAIN RESULTS AND THE ROLE OF CHANCE: Eleven jurors decided that Australia should allow children to be born following mitochondrial donation; 7 of whom added conditions such as the need to limit who can access the intervention. Three jurors decided that children should not (or not yet) be born using this intervention. All jurors were particularly interested in the reliability of evidence, licensing/regulatory mechanisms and the rights of children to access information about their oocyte donors.

LIMITATIONS, REASONS FOR CAUTION: Jurors' views were well informed and reflected critical deliberation and discussion, but are not intended to be representative of the whole population.

WIDER IMPLICATIONS OF THE FINDINGS: When presented with high quality evidence, combined with opportunities to undertake structured deliberation of novel reproductive technologies, members of the public are able to engage in detailed discussions. This is the first study to use an established deliberative method to gauge public views towards mitochondrial donation.

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Introduction

Mitochondrial donation is an emergent assisted reproductive technology that involves producing an embryo or oocyte containing third party mitochondria, to provide an additional reproductive option to women at risk of transmitting conditions caused by mutations in mitochondrial DNA (Richardson et al., 2015). As a relatively novel intervention, several aspects remain contested. For example, debates continue over safety (Reinhardt et al., 2013; Appleby, 2015; Wolf et al., 2015; Hyslop et al., 2016; Eyre-Walker, 2017; Dobler et al., 2018), whether it constitutes germ-line gene therapy (Newson and Wrigley, 2017), whether the value of genetic kinship justifies its use (Rulli, 2016) and whether it should be limited to those at risk of transmitting disease or made available to other groups, such as lesbian couples (Cavaliere and Palacios-Gonzalez, 2018). There are also debates about the process of public engagement in the lead-up to regulation (Haimes and Taylor, 2015; Herbrand, 2017).

Specific legal regulation pertaining to mitochondrial donation exists only in the UK, where it is allowed under licence for certain couples at risk of transmitting serious mitochondrial disease (Dimond and Stephens, 2018a). Relevant licences have been granted at one clinic in the UK (Human Fertilisation & Embryology Authority, 2017; Sherratt, 2018). Mitochondrial donation has been used to avoid the birth of a child with mitochondrial disease in Mexico, although its legal permissibility in that jurisdiction remains contested (Ishii, 2017; Palacios-González and de Jesús Medina-Arellano, 2017). It has also been used for the contentious practice of 'oocyte rejuvenation' in the Ukraine, where mitochondrial donation is permissible due to a regulatory gap (Bredenoord and Appleby, 2017; Ishii, 2017).

In other jurisdictions mitochondrial donation is precluded either by regulatory events such as a 2015 appropriations bill in the USA (Cohen and Adashi, 2016), or by laws which pre-date this technology, as is the case in Australia. Australia operates under a federated legal system. Clinical use of mitochondrial donation falls under existing Australian Commonwealth and State level laws that prohibit human cloning and regulate embryo research (Ludlow, 2018). Research on one method of mitochondrial donation (pronuclear transfer) may be possible in Australia under licence, but no licences have yet been granted. A 2018 Australian Commonwealth Senate Committee Inquiry recommended that regulators explore changing relevant laws to allow mitochondrial donation and that further public consultation was needed (Senate Committee, 2018).

Studies suggest that clinicians, oocyte donors and patients in various countries support (or cautiously support) the availability of mitochondrial donation (Hens et al., 2015; Engelstad et al., 2016; Herbrand and Dimond, 2018). However, with the exception of the UK, there has

been little public deliberation. The UK's Human Fertilisation and Embryology Authority commissioned studies to explore public views on the use of these techniques (Human Fertilisation & Embryology Authority, 2013), which found qualified support for mitochondrial donation under appropriate oversight.

While there is enthusiasm for mitochondrial donation among clinicians and researchers in Australia and increasing interest from policy-makers (Senate Committee, 2018), there has been little public debate. With the objectives of informing policy-making and eliciting key issues as viewed by a group of well-informed members of the public, we held a citizens' jury into the acceptability of mitochondrial donation.

Citizens' juries are one approach to engaging the broader public in complex social and policy problems (Abelson et al., 2013; Wise, 2017). They involve a group of lay citizens coming together to deliberate on evidence about a challenging policy issue, with each juror contributing to a 'verdict' in response to the 'charge' (Degeling et al., 2015). When provided with the right conditions, those without formal training or expertise are capable of coming to a reasoned and informed decision that authentically reflects their preferences and values (Blacksher et al., 2012). Citizens' juries have been used to address questions relating to the use of new reproductive technologies, such as choosing children's characteristics (Iredale et al., 2006) and public funding (Hodgetts et al., 2014). They have also been used to debate a wider range of issues in health policy (Street et al., 2014; Degeling et al., 2015). Juries are not designed to capture a single unified public opinion (Karpowitz and Raphael, 2014; Degeling et al., 2015). Nor do they intend to capture a statistically representative sample of 'the general public'. Participants are recruited to capture diversity of experiences and backgrounds in a community, and the deliberation process aims to redress power imbalances wherever feasible. We asked our jury to deliberate whether Australia should allow children to be born following mitochondrial donation.

Materials and Methods

Study population and participants

An independent research recruitment company used a commercially available list of mobile telephone numbers to recruit jury members of mixed genders, ages, ethnicities and levels of educational attainment. There were no specific inclusion criteria. Exclusion criteria were as follows:

- Unable to speak or understand English.
- Unavailable on relevant dates.
- Opposed to all forms of IVF.
- Person or their partner had received, was currently receiving or planned to undergo ART.

- Person, their spouse/partner, another member of their family or a close friend had been diagnosed with mitochondrial disease or was being investigated for this.

Deliberation depends on individuals being able to put forward positions, listen to the position of others and then reflect on and potentially refine their own arguments and decisions. We sought to exclude people who were opposed to IVF, as use of this form of ART is a precondition for mitochondrial donation and we wanted debate among jurors to be focused on mitochondrial donation rather than IVF more generally. It was also necessary to exclude individuals with experience of ART or mitochondrial disease from participation because we did not want jurors' consideration of the evidence presented by experts to be influenced by the personal experiences of a fellow juror. This step was also taken as an ethical necessity as a juror who has had these experiences may find the subject matter and discussion upsetting, particularly if their experiences were discounted by others during deliberation. Sixteen jurors were recruited, of whom 14 attended (Table I). This number of jurors is considered appropriate (Street

et al., 2014); it provides enough participants to foster a deliberative discussion, and is a small enough group such that everyone can participate in depth.

Jury processes and procedures

The jury was planned by the authors over a 6-month period, in line with published recommendations for citizens' juries (Thomas *et al.*, 2017). The jury format is provided in Table II, while the full question jurors were asked to address is shown in Table III. The jury ran over 1.5 days in July 2017.

Evidence was provided to jurors in the form of 20-min pre-recorded slide presentations from four experts: two factual presentations and two that provided substantive and opposing positions, as follows:

- Factual information about mitochondrial genetics and mitochondrial disease (C.M.S.).
- Factual information about treating and preventing mitochondrial disease (D.R.T.).
- A presentation from the position of concern regarding health risks that might arise in children born via mitochondrial donation (D.K.D.).
- A presentation from the position in favour of legalizing mitochondrial donation in Australia (S.M.).

Each expert developed their presentation in response to a detailed 'brief'. Draft evidence was reviewed by A.J.N. and presentations were revised as required. Copies of all expert evidence videos are available on request.

Key to the design and content of this jury was the motivation to ensure that jurors were able to compare two alternative futures, in this case one in which children are allowed to be born following mitochondrial donation and one in which they are not. The research team wanted to avoid narratives from existing patients interfering with jurors' ability to compare these futures, particularly because mitochondrial donation will not offer a cure for existing patients living with mitochondrial disease. Therefore, a patient story or narrative was not included as part of the evidence. The baseline presentation briefly referenced existing peer-reviewed global evidence about patient attitudes to mitochondrial donation, including that it was not universally endorsed. It was recognized that while any reference to patient views could have an emotional impact on jurors, the patient narrative should not be ignored entirely.

The jury was also structured to allow the jurors to determine what ethical issues were relevant to consider. The research team used a checklist to ensure issues were not overlooked or summarily dismissed. Ethical issues were explicitly identified by the facilitators (S.de.L. and L.G.) as they were raised. Jury consensus was sought but not forced—dissenting views and minority positions were recorded as part of the verdict.

Data collection

The following data were collected during the jury:

- Demographic information (Table I). The jury had higher than average educational attainment and high socioeconomic status.
- Quantitative data, via an attitudes survey (see Supplementary File 1) and juror satisfaction survey (see Supplementary File 2).
- Qualitative data: all question and deliberation sessions, including the closed deliberation by jurors, were audio recorded. Key issues discussed and the jury verdict were also recorded via notetaking.

This jury utilized the term 'mitochondrial donation' as this term has been prevalent in the literature. However, it is one of several used to describe this intervention, with others including 'mitochondrial replacement' and 'human nuclear genome transfer' (Baylis, 2017; Dimond and Stephens, 2018b).

Table I Demographic information of jury participants.

	n
Age (years)	
18–24	2 (2)
25–34	3
35–44	1
45–54	2
55–64	5
65+	1
Gender ^a	
Female	8
Male	6 (8)
Ethnicity/cultural background ^b	
Australia	8
China	2
Brazil	1
Canada	1
Indonesia	1
Sri Lanka	1
Educational attainment	
High School Certificate or equivalent	2
Trade certificate	4
Undergraduate degree	4
Postgraduate degree	4
Sociodemographic status ^c	
Low	0
Middle	4 (6)
High	10

^aAll participants identified as female or male.

^bUsing the Australian Standard Classification of Cultural and Ethnic Groups (ASCCG) (Australian Bureau of Statistics, 2016).

^cBased on the Socio-Economic Indexes for Areas (SEIFA) (Australian Bureau of Statistics, 2011).

Figures given in parentheses represent the total recruited. Figures not in parentheses represent those who attended.

Table II Jury format.

- A group of citizens who met the eligibility and inclusion criteria were convened and met for 1.5 days.
- The question in Table III was put to the jurors as the question for deliberation.
- Jurors received a detailed workbook, including background scientific and legal information.
- Attitudes surveys were completed at the start of Day 1, end of Day 1 and start of Day 2.
- Jurors heard fact-based information and evidence presenting opposing positions from expert witnesses (see text) and asked questions of each witness.
- There were facilitated deliberations at the end of Day 1 and start of Day 2.
- The jury then had an unfacilitated session of deliberation, to reach a verdict. Members of the research team were on hand if required.
- The 'verdict' and supporting reasons (including dissenting views) was reported to the research team in a final facilitated session.
- The jury completed a satisfaction survey.

Table III The question posed to the jury.

The jury was asked to answer this question:
Should Australia allow children to be born via mitochondrial donation?
Which of these options do you endorse?

(a) Australia SHOULD allow children to be born via mitochondrial donation.
OR
(b) Australia should NOT allow children to be born via mitochondrial donation.

Reasons for option choice:

- Please explain the reasons for why you have made this decision.
- What conditions (if any) would you give on the position you have taken?

Ethical approval

Ethical approval for this study was granted by the University of Sydney Human Research Ethics committee (reference 2017/291).

Results

Topics discussed

The jurors canvassed a wide range of scientific and ethical aspects of mitochondrial donation during the evidence sessions, facilitated discussions and in their final deliberation (Table IV). An issue raised frequently was empathy with families living with mitochondrial disease and with those who had a high chance of passing it to their children.

However, jurors were also motivated to ensure that children born of this intervention would not suffer harm. They expressed keen interest in knowing more regarding safety of this technique, with some jurors wishing to see original sources of evidence rather than expert reports. They also expressed some concern about currently available research data (such as how much there was, from where it was obtained and in which species). Jurors also requested data on aspects such as risks arising from heteroplasmy being present in the cells of children born.

There was broad support for a licensing system in which both the clinic providing mitochondrial donation and the couple seeking it procure licences. Jurors discussed two different models of licensing. In the first, particular attention should be paid to safety, informed consent, mandating counselling and promoting awareness of this technique among the wider public (including as a method to boost recruitment

for oocyte donation). The second licensing model incorporated all of these aspects but also added a restriction to access, where only women at high risk of transmitting serious mitochondrial disease would be eligible. Jurors who supported this model (see below) believed further research is needed to determine such a threshold for access.

Jurors valued genetic kinship between parents and children but some did not take this view so far as to say that it would justify mitochondrial donation in any circumstances. Many felt the intervention should be provided based on medical need, rather than a couple's desire to have a genetic link between a child and both intending social parents.

Jurors agreed that people seeking mitochondrial donation should agree to do so under a research protocol. They endorsed longitudinal follow-up, albeit recognizing that there may be practical difficulties when a family declines this. There was also some discussion regarding whether counselling for couples seeking mitochondrial donation should include aspects such as alternatives to using mitochondrial donation.

Jurors agreed that any legal regulation of mitochondrial donation needs to clarify the parental status of an oocyte donor, to protect all parties involved. The group also discussed the rights and interests of the donor, considering this mainly from the perspective of the child. There was a split condition to the verdict among those voting 'yes', regarding access to (and veto of) identifying information about donors. A majority view was that when any children born from mitochondrial donation reach the age of majority, they should have a right to know their donor. A further suggestion was that the donor could nominate whether she wanted contact.

There was also some debate among the group as to whether the '3 parent' term was appropriate. A majority view was that the contribution of mitochondrial DNA was very small and that mitochondria do not confer parenthood.

All jurors agreed that mitochondrial disease and mitochondrial donation were issues that required greater public awareness. They were also enthusiastic for citizens to be involved in debate over its introduction.

Jury verdict

The jury returned a majority verdict (11 of 14 jurors) favourably answering the question: 'Should Australia allow children to be born following mitochondrial donation?' The 11 jurors who voted 'yes' were divided into those who voted 'yes, unconditionally' (4/11) and 'yes with conditions' (7/11). The three jurors who voted 'no' comprised two who voted 'not yet' and one who held absolute opposition to mitochondrial donation.

Table IV Issues raised by jurors.

The technology	<ul style="list-style-type: none"> • It's changing the egg—this is new, even for IVF • Would it have big effects in the long term, on evolution? • Is it natural? • How expensive is it? • How significant is it to have more than two genomes? • It might get out of hand—if we do this, what else might we end up with? • Is there enough evidence yet about the risks and chance of success? Risks for whom? Who has reviewed it? Who decides?
Effects on the child to be born	<ul style="list-style-type: none"> • Would mitochondrial donation work? Would it benefit the child in the longer term? • Would mitochondrial donation change the child's other characteristics in some way? Would it mean that the child would not look like its parents? • Could something go wrong and cause harm to the child? • What will the experience of those born be like?
Parents' understanding and expectations of the intervention	<ul style="list-style-type: none"> • What would the parents be told about mitochondrial donation? • Would parents expect an absolute guarantee that the child would not get mitochondrial disease? Would they litigate if it went wrong? • How important is a genetic connection? Are there reasonable alternatives for parents to having an affected child, such as adoption?
The egg (oocyte) donor	<ul style="list-style-type: none"> • Should the donor be anonymous or known to the parents? • Should the donor be known to the child? Would the donor want to have a relationship with the child? • Is it feasible to 'match' egg donors [haplotype matching, as suggested by one expert witness] to reduce risk for the child? • Who would be a suitable donor?

Those who voted 'yes unconditionally' (4 of 14 jurors) did so based on sympathy for those who live with mitochondrial disease and belief that mitochondrial donation would help. This outweighed any safety concerns. They supported the first licensing model described above, which did not involve restricting mitochondrial donation to those at risk of transmitting severe mitochondrial disease. This group also reported high confidence in regulatory regimes.

Those who voted 'yes, with conditions' (7 of 14 jurors) broadly concurred with the above reasons. However, they placed greater emphasis on more restrictive licensing—the second model described above, including a risk threshold for access. These jurors were split over whether the child born has a right to know the details of the oocyte donor once they turn 18.

Those (2 of 14 jurors) who voted 'not yet' did so because they felt they had not yet seen enough evidence as to the safety of the technique over time. This uncertainty should be the primary consideration and more research in humans was needed.

The juror who voted 'no' without exception (1 of 14 jurors) was concerned that mitochondrial donation is the first deliberate human germline intervention. This juror also placed emphasis on the contribution of mitochondria to human characteristics.

Evaluation of jury processes

Jurors' self-rated confidence in their knowledge of mitochondrial disease and mitochondrial donation rose during the jury. Confidence rose by a mean of 4.11 points (on a 10-point Likert scale), from a mean (± 1 standard error) of 3.86 (± 0.50) at the start of Day 1, to a mean of 7.96 (± 0.39) at the start of Day 2.

Juror attitude surveys consistently showed a majority view in favour of mitochondrial donation. However as the jury progressed, some jurors changed their mind about their answer to the charge (question).

Four jurors had changed their mind by the end of Day 1 (2 from 'uncertain' to 'yes'; 1 from 'uncertain' to 'no'; and 1 from 'yes' to 'no').

Jurors indicated a high level of satisfaction with the jury. They felt their opinions were respected by the group (mean 8.21 ± 0.47 on a scale of 1–10), that the process was fair (mean 8.86 ± 0.29) and that they were listened to by the facilitator (mean 9.0 ± 0.38). They also found the evidence presented to be helpful (mean 8.36 ± 0.56). Jurors were slightly less positive about feeling part of the group at the jury's conclusion (3.79 ± 0.28 on a scale of 1–5) and whether the jury will influence policy in Australia (mean 3.36 ± 0.36 on a scale of 1–5).

Discussion

After hearing and interrogating relevant evidence and engaging in structured deliberation, 11 of 14 members of a citizens' jury decided that Australia should allow children to be born following mitochondrial donation. The majority view indicating cautious support for mitochondrial donation is consistent with other research in different populations and using different methods, including clinicians (Hens *et al.*, 2015), oocyte donors (Engelstad *et al.*, 2016) and potential users of this intervention (Engelstad *et al.*, 2016; Herbrand and Dimond, 2018).

In the UK, commissioned research with patients and the public indicated 'general support' for mitochondrial donation (Human Fertilisation & Embryology Authority, 2013). Yet while UK participants appeared to see mitochondrial donation as analogous to tissue donation (meaning donation could be anonymous), the discussion in this jury focused more on information rights for the child born. A further point of difference regards evidence of safety. Participants in the UK reported their trust in experts who would make determinations regarding safety. However jurors in this study showed significant interest in the details of relevant research studies rather than reports from expert bodies.

The breadth of issues identified by jurors shows that citizens' juries can be a valuable addition to discussions of emerging reproductive technologies. This previously unaware group of citizens demonstrated sustained and in-depth reasoning and identified a large range of scientific, ethical and legal considerations. Jurors were very engaged in the process and keenly interested in mitochondrial donation, despite having little or no prior knowledge.

Even though there was broad in-principle support for using mitochondrial donation, jurors remained concerned about timescales and what constitutes 'enough' evidence to allow mitochondrial donation in Australia. They did not unconditionally accept assurances from those expert witness who claimed that those born of mitochondrial donation were very unlikely to develop mitochondrial disease. This desire likely reflects the ongoing scientific debate on benefits and costs of mitochondrial donation—a debate also discussed by expert witnesses.

Jurors were also keenly interested in the functions that mitochondria perform and the contribution that mtDNA has, suggesting that well-informed populations may not always accept analogies such as the 'battery analogy' used in the UK (Nuffield Council on Bioethics, 2012). Further, while they valued genetic kinship between parents and children, jurors did not spend a great deal of time debating the '3 parent' issue that has dominated media discourses (Toynbee, 2015; Bowden, 2017).

These responses suggest that public citizens perceive aspects such as timescales and scientific uncertainty differently from experts. While citizens can be willing to accept uncertainty, and agree with cautious implementation, they also wish to consider evidence in a local context. This finding is also relevant to the question of whether mitochondrial donation should be framed as a cure for mitochondrial disease (Haimes and Taylor, 2017; Herbrand, 2017).

The study is subject to some limitations. Participants tended to have higher levels of educational attainment than average in Australia, which is broadly consistent with the population of Sydney from which they were recruited (Australian Bureau of Statistics, 2016). Clearly a jury of 10–14 people cannot be representative of 'the general public'. But it is possible to derive a sense of what an informed public would advise from a smaller group who are given factual information and time to deliberate (Burgess, 2014; Karpowitz and Raphael, 2014). A strength of this study is that by providing extensive information from a range of experts, and ensuring conditions for reasonable and extended debate, citizens' juries elicit more considered judgements than other social research methods. Further research is needed to ascertain the extent to which citizens from other geographic areas would come to similar conclusions and recommendations. Juries could also explore the value of and justification for genetic kinship, and whether mitochondrial donation should be limited to those at risk of passing on mitochondrial disease or be more widely accessible.

This study suggests that members of the public can actively engage in questions of the acceptability of emerging reproductive technologies such as mitochondrial donation. Their views provide an important indication of where debate may arise. Deliberative engagement allows for discussion of both the potential and uncertainty of mitochondrial donation. As the Australian government moves forward with its consideration of mitochondrial donation, this jury provides an important first indication of public acceptance.

Supplementary data

Supplementary data are available at *Human Reproduction* online.

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Authors' roles

A.J.N. conceived and led the study and analysis and wrote the first draft of this article. S.de.L. and C.D. were co-investigators and were extensively involved in all aspects of the study. D.K.D., S.M., C.M.S. and D.R.T. were expert witnesses at the jury. D.K.D. also assisted with statistical analyses. L.G. was an expert facilitator at the jury (including leading two deliberation discussions and undertaking an initial thematic analysis) and participated in final jury planning meetings. All authors contributed to critical review and discussion of the article and read and approved the final version.

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Conflict of interest

This study was funded by a grant that required a community partner. The Mito Foundation provided 17% of the funding and in-kind administrative support. The University of Sydney retained full academic oversight of the study. Author and expert witness Sean Murray is Chief Executive Officer of the Mito Foundation and reports holding shares (stock) in Amgen. Authors Carolyn Sue and David Thorburn report grants outside this work from the Mito Foundation. Damian Dowling and Lynn Gillam report no conflicts of interest.

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