Sperm quality in New Zealand: is the downward trend continuing?
Mary Birdsall, John Peek, Sumithra Valiapan

ABSTRACT
AIM: To investigate whether the decline in sperm concentration in New Zealand sperm donors observed from 1987 to 2007 continued in the period 2008–2014.
METHOD: A retrospective study from 2008 to 2014. The first semen sample of 285 men presenting as sperm donors in Auckland and Wellington was analysed for sperm concentration, seminal fluid volume and the percentage of motile sperm. These results were compared to results from 1987 to 2007 from the same clinics.
RESULTS: The decline in semen volume and sperm concentration observed between 1987 and 2007 did not continue in 2008–2014. Sperm concentration decreased from 1987 until some time between 1997 and 2001, and has remained stable at an average of 62x10^6/ml between 2001 and 2014. Sperm motility declined significantly (8%) in the period 2008–2014, but there was no significant change over the total period studied, between 1987 and 2014.
CONCLUSION: After a decline between 1987 and sometime during 1997–2001, the sperm concentration in men presenting as donors remained unchanged between 2002 and 2014, suggesting semen quality has not changed in New Zealand men over the last decade.

There have been concerns over a possible global decline in semen quality since the 1930s.1,2 In 2008, we reported an annual reduction of 2.5% in sperm concentration in a study of sperm quality among New Zealand men presenting as sperm donors over 20 years.3 This trend exceeded the 1% average global decline reported by Carlsen et al.1 Subsequently, Swan et al2 reported a 2.3% and 0.8% annual decline for European and American men respectively. Rolland et al4 reviewed one of the largest study populations to date, and reported a 1.9% decline among French men.

A group in Israel5 found deterioration in sperm quality in their intrauterine insemination (IUI) sperm donation program, leading them to postulate they may need to utilise in-vitro fertilisation instead of IUI in the future.

Recent papers from France, Spain and Finland have also reported deterioration in sperm quality.6-8 However, other researchers have reported different results; Jorgensen et al9 found an increasing trend in sperm concentration and total sperm count among Danish men and, in Sydney, Costello et al10 found no decline in semen quality among their sperm donors.

There is ongoing debate that this geographical heterogeneity is due to diverse influences from environmental, occupational and lifestyle factors.2,6 A systematic review11 recently concluded that there is a lack of evidence to confirm a worldwide decline in sperm counts.

The present study adds another 7 years of data to our original analysis to test whether the trends of falling semen volume and sperm concentration have continued. The implication is that a continuing fall in semen quality among men presenting as donors may reflect a continuing decline in male fertility, and the prospect of more New Zealand couples requiring Assisted Reproductive Technology in the future.
Methods

Subjects: This study added 285 men, recruited between January, 2008, and July, 2014, to the 975 men included in the original study. The median ages of men in the two periods were 36 and 35. The men were potential sperm donors recruited by Fertility Associates. The study excluded men recruited by patients as personal donors. Recruitment was by advertising in local newspapers, magazines and billboards. The clinic had an upper age limit of 50, which was reduced to 45 in 2005. Proven fertility or marital status was not required nor mentioned in advertising.

Semen analysis: Samples were collected by masturbation, with two to four days abstinence recommended. Semen volume, sperm concentration and percentage motile sperm were measured, from which were calculated the total number of sperm and the total number of motile sperm. Samples were analysed within two hours. Semen volume was measured by aspirating the whole liquefied sample into a 5 ml or 10 ml graded pipette. Between 1987 and 2002, sperm concentration was determined using formalin immobilised sperm in a hemocytometer. Motility was assessed on a slide with cover slip, which had a sample depth of about 20 microns. From 2002 onwards, 20 micron deep counting chambers (MicroCell) were introduced for measuring both concentration and motility. At least 200 sperm were measured for both these parameters.

Statistical analysis: For the initial analysis, semen volume, sperm concentration, motility, total number of sperm and total motile sperm were cube root transformed before multivariate linear regression to look at temporal trends. Since analysis of transformed and untransformed data gave similar results, untransformed data was used in this paper for simplicity, as in the previous paper.

Results

Temporal changes in semen volume, sperm concentration and motility between 1987 and 2014 are shown in Figures 1, 2 and 3. There were statistically significant falls in semen volume and sperm concentration over the period 1987–2007, as presented in the initial report, and over the whole period 1987–2014 (Table 1).

Semen volumes for 2008–2014 were 6% higher than predicted by the trend seen in the original study, but this was not significant (p=0.14). The mean semen volume in the periods 2001–2007 and 2008–2014 were similar, at 3.3 and 3.2 ml, suggesting no change between these periods.

Sperm concentrations for 2008–2014 were 39% higher than predicted by the trend seen between 1987 and 2007, which was significant (p<0.001). The mean sperm volume in the periods 2001–2007 and 2008–2014 were similar at 63 x 10^6/ml and 61 x 10^6/ml, indicating that sperm concentrations fell from 1987 and sometime between 1997 and 2001, but have remained unchanged since (Figure 3, three order polynomial regression line).

Sperm motility was 16% lower in the period 2008–2014 than the trend predicted from the initial study (p<0.001). Mean motility in the periods 2001–2007 and 2008–2014 were 61% and 53%. However, the trend over the total period 1987–2014 was slight and not significant (Table 1).

Table 1: Change in semen quality over time in 1,260 potential sperm donors

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<th>Mean</th>
<th>Trends</th>
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<td>Previous</td>
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<td>Volume (ml)</td>
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<td>(million/ml)</td>
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<td>62</td>
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<td>Motility (%)</td>
<td>59</td>
<td>53</td>
<td>57</td>
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Table 1: Change in semen quality over time in 1,260 potential sperm donors
Figure 1: Sperm volume in 1,260 potential sperm donors recruited between 1987 and 2014

**Semen Volume (ml)**

![Graph of Semen Volume](image1)

Figure 2: Sperm motility in 1,260 potential sperm donors recruited over 27 years recruited between 1987 and 2014

**Sperm Motility (%)**

![Graph of Sperm Motility](image2)
Discussion

This study has shown that the decline in sperm concentrations in New Zealand sperm donors reported in 2008 has not continued.

Our previous study\(^3\) showed a significant decline in sperm concentration over the period 1987 to 2007. Post hoc analysis suggested the decline was limited to the first half of the period studied. The findings from the present study confirm this observation, so we can conclude that sperm concentration declined from 1987 to sometime between 1997 and 2001, but has remained stable at a mean of 61–63 x 10^6/ml from 2001 onwards.

More than one hundred peer reviewed articles have been published on trends in sperm counts,\(^9\)-\(^12\) with varying conclusions. One extensive review suggested a decline in sperm counts from 1938 to 1972, with no decline over the next 20 years.\(^13\)

The present study did show lower sperm motility in 2008–2014 compared to 1987–2007, but there was no trend when the whole period was considered.

It is difficult to know whether this observed reduction in sperm motility will be part of a trend or whether it is due to fluctuations in laboratory processes. Quality control for sperm motility measurement over many years is more difficult than for sperm concentration. Among those who have reported falling sperm concentration, some have observed a concomitant fall in motility,\(^5\),\(^6\) while others have not.\(^4\),\(^7\),\(^14\),\(^15\)

There have been a number of theories proposed to explain deteriorating semen quality, and these have included both environmental and lifestyle factors. Reductions in semen quality have also been associated with an increasing rate of testicular cancer, cryptorchidism and hypospadias, as well as a decline in levels of androgen hormones.\(^6\)

One postulated cause for reduced semen quality is exposure to chemicals in the environment that are endocrine disruptors.\(^10\),\(^11\) Industrialisation has resulted in the release of endocrine disruptors originating from pesticides, herbicides, cosmetics, preservatives, cleaning materials, private waste and pharmaceutical products into the environment. Many of these chemicals have long half-lives and have been detected in the environment decades after their release.\(^11\) Exposure to pesticides at both occupational and environmental levels may be associated with reduced sperm quality.\(^16\)

Another putative cause is exposure to toxins and/or environmental estrogenic compounds during fetal growth, which would reduce the level of spermatogenesis in the testis as an adult.\(^4\),\(^17\) Recent studies on...
smoking in pregnancy indicate an association between prenatal tobacco exposure, lower sperm concentration and testicular cancer in the male offspring.7

We have no information with respect to the presence or absence of toxicants or pollutants in our population during the time period of our study. Determining exposure is difficult because good quantitative exposure data is challenging to acquire and exposures in utero are even more difficult to measure. It is important to note that some toxins are being reduced, which may affect our findings and sperm concentrations into the future. For instance, DDT (dichlorodiphenyltrichloroethane) was widely used in New Zealand agriculture as an insecticide, but its use was phased out from the 1970s and finally banned in 1989. DDT exposure has been shown to have detrimental effects on male fertility.18 Similarly, cigarette smoking is declining, with fewer women smoking during pregnancy.

A limitation of our study is that it is a retrospective analysis. Men who choose to be sperm donors may also not be representative of the general population; for instance, sperm donors tend to be well educated.19 Although there are valid concerns about how representative of the general population sperm donors might be, such men constitute a fairly homogenous population in age and background, and thus trends in this group may reflect trends in the whole population.6 A further limitation is that we did not collect lifestyle information from potential donors at the time of their first semen sample, such as smoking, alcohol intake, recreational drug use, obesity and self-assessment of stress. These are common confounding factors which have been associated with a reduction in semen quality, although better quality evidence is needed to confirm the impact of most of these effects.4,11,17

Merzenich, et al20 found that older age contributed significantly to a decline in sperm concentration and motility. Older paternal age is negatively associated with time to pregnancy as well as a declining likelihood of pregnancy. Age is associated with an approximately 4% reduction in fecundability per increasing year.21 The average age of our participants was 35 years, and increased only slightly between 1987 and 2014. This is older than in most studies of donors, but similar to the age of men trying for pregnancy in New Zealand, where the average age at birth is 30 for women and 32 for men.

The latest systematic review on sperm quality published recently11 concluded that there is insufficient strong evidence to confirm a worldwide decline in sperm counts, with no scientific proof of a causative role for endocrine disruptors. However, there is sufficient evidence to entertain that there may be regional changes in semen quality, especially in sperm concentration, over time. It is prudent to consider what effect these might have if maintained on human fertility and fecundity, since sperm concentration has been found to be associated with time to pregnancy in natural conception.22 Sperm concentration is associated with various aspects of sperm quality,23 so a decline in sperm concentration may signal an increasing need for fertility services. The present findings are reassuring, in that if there was a decline in sperm concentration in New Zealand men, as indicated between 1987 and 2001, it has stopped.
Competing interests: Nil

Acknowledgements:
The authors thank Dr Chris Frampton for advice on statistical analysis and the staff of Fertility Associates in Auckland and Wellington for donor recruitment and semen analysis over the years. We also acknowledge the contribution of all sperm donors in our clinic.

Author information:
Sumithra D Valiapan, Fellow Reproductive Medicine, Fertility Associates, Ascot Central, Auckland; John C Peek, General Manager - Quality, Information, Science Fertility Associates, Ascot Central, Auckland; Mary A Birdsall, Medical Director, Fertility Associates, Ascot Central, Auckland

Corresponding author:
Mary A Birdsall, Fertility Associates, Ascot Central, 7 Ellerslie Racecourse Drive, Remuera, Auckland 1051, New Zealand.
mbirdsall@fertilityassociates.co.nz

URL:

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