RESEARCH LETTER

Effects of firefighting on semen parameters: an exploratory study

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Lay summary

Firefighters are occupationally exposed to heat intensities and chemicals known to affect fertility. Twenty firefighters participated in an exploratory study assessing fertility of firefighters via an online survey and semen analysis. Data analysis included consideration of demographic characteristics, reproductive history and occupational exposures. Overall, firefighter semen parameters were below World Health Organisation reference values designating fertility in men. Firefighters younger than 45 years had a higher incidence of abnormal semen parameters (42%) than those aged 45 years or greater (9%). Increased rank and higher levels of occupational and/or personal hygiene were associated with improved semen quality. Increased frequency of fire exposure was associated with a reduction in normal forms, volume, sperm concentration and total sperm count. Sperm clumping was greater than 10% in 26% of samples, suggesting reduced semen quality. This exploratory study provides novel data that support the hypothesis of an association between semen quality and firefighter's occupational exposure to toxic environments.
Effects of firefighting on semen parameters

There is, however, a scarcity of data on firefighter semen parameters. This exploratory study provides novel data that support the hypothesis that there is indeed an association between firefighter semen quality and firefighter’s occupational exposure to toxic environments. These results will add value to the design of a well-powered and targeted investigation aimed at maintaining and improving the health and well-being of firefighters, their families and offspring.

Table 1 Characteristics of participants in semen exploratory study, with WHO (2010) reference ranges presented. Data are presented as n or as mean ± s.d.

| Characteristics                          | Values   | WHO 2010 |
|------------------------------------------|----------|----------|
| Total participants                       | 20       |          |
| Age, years*                              | 45 ± 10  |          |
| <45                                      | 11       |          |
| ≥45                                      | 9        |          |
| Active duty (current fire exposure)      | 18       |          |
| Rank firefighter                         | 18       |          |
| Rank station officer/captain             | 2        |          |
| Full-time firefighter                   | 16       |          |
| Part-time firefighter                   | 4        |          |
| Years in job*                            | 20 ± 10  |          |
| Tobacco smoker                           | 0        |          |
| Abstinence in days                       | 3.8 ± 1.1|          |
| Minutes to analysis                      | 104 ± 66 |          |
| Successfully conceived at least 11 child | 15       |          |
| Unable to conceive in 1 or more attempts | 1        |          |
| Difficulty conceiving                    | 6        |          |
| Unknown cause                            | 4        |          |
| Abnormal semen parameters                | 1        |          |
| Hormone imbalance                        | 1        |          |
| Underwent IVF in any instance            | 4        |          |
| Reported time to pregnancy               | 7        |          |
| ≤12 months                               | 5        |          |
| >12 months                               | 2        |          |
| Experienced miscarriage(s)               | 3        |          |
| Negative pregnancy or birth outcomes†   | 7        |          |
| Semen volume                             |          |          |
| 5th%                                     | 0.6      | 1.5      |
| 50th%                                    | 2.0      | 3.7      |
| 95th%                                    | 5.0      | 6.8      |
| Sperm concentration 10%/mL               |          |          |
| 5th%                                     | 12       | 15       |
| 50th%                                    | 73       | 73       |
| 95th%                                    | 180      | 210      |
| Total sperm count 10^6/M                 |          |          |
| 5th%                                     | 33       | 39       |
| 50th%                                    | 150      | 260      |
| 95th%                                    | 450      | 800      |
| Total motile %                           |          |          |
| 5th%                                     | 34       | 40       |
| 50th%                                    | 56       | 61       |
| 95th%                                    | 73       | 78       |
| Progressive motility %                   |          |          |
| 5th%                                     | 16       | 32       |
| 50th%                                    | 46       | 55       |
| 95th%                                    | 71       | 72       |
| Normal forms %                           |          |          |
| 5th%                                     | 3.1      | 4        |
| 50th%                                    | 9.0      | 15       |
| 95th%                                    | 21       | 44       |

*Age and duration of employment data were collected in 5-year increments (employment had one option of <1 year). To calculate the crude mean, the midpoint of each bracket was utilised. **These data are from firefighters self-reporting via the Stage 1 survey. †Negative birth outcomes include miscarriage, still birth, pre-term birth, low birth weight, astigmatisms, attention deficit hyperactivity disorder (ADHD), club foot, dyspraxia, and asthma.

Overall, firefighter semen parameters were below WHO reference values in numerous categories, with increased frequency of fire exposure, and with both increased breathing apparatus across fire types, and with both increased showering post fire incidents and hand washing throughout the shift. Negative associations were detected for normal sperm count, volume, sperm concentration and total sperm count with increasing frequency of fire exposure. Sperm agglutination was >10% in 26% of samples.

This is the first investigation published on Australian firefighter sperm quality. Internationally, studies exist on firefighter reproductive history, with suggested links to toxic work (Petersen et al. 2019). There is, however, a scarcity of data on firefighter semen parameters. This exploratory study provides novel data that support the hypothesis that there is indeed an association between semen quality and firefighter’s occupational exposure to toxic environments. These results will add value to the design of a well-powered and targeted investigation aimed at maintaining and improving the health and well-being of firefighters, their families and offspring.

Declaration of interest
There is no conflict of interest present within this research work. Although the lead researcher undertakes research while having a primary employment within a fire service, a comprehensive intellectual property, confidentiality and data sharing agreement has been signed between the lead researcher, employer and the University of Queensland, reducing any possibility of a conflict of interest.

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Author contribution statement
M E led study conception, the management of external relationships, participant recruitment, data analysis, and manuscript drafting, reviewing and editing. L M T and X W were involved in study progression post inception, manuscript shaping, editing and review, and providing expert guidance. A P W B was involved in results analysis, manuscript shaping and editing. D B was involved in data analysis, manuscript shaping, editing and review, and providing expert guidance. All authors were involved in the discussion of results and consideration of limitations.
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References
Hellstrom WJG, Overstreet JW, Sikka SC, Denne J, Ahuja S, Hoover AM, Sides GD, Cordell WH, Harrison LM & Whitaker JS 2006 Semen and sperm reference ranges for men 45 years of age and older. Journal of Andrology 27 421–428. (https://doi.org/10.2164/jandrol.05156)
Petersen KU, Hansen J, Ebbehoej NE & Bonde JP 2019 Infertility in a cohort of male Danish firefighters: a register-based study. American Journal of Epidemiology 188 339–346. (https://doi.org/10.1093/aje/kwy235)
WHO 2010 WHO Laboratory Manual for the Examination and Processing of Human Semen, Fifth edition. World Health Organization. (available at https://www.who.int/publications/i/item/9789241547789)

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