

FINDING INTO DEATH WITHOUT INQUEST

*Form 38 Rule 60(2)
Section 67 of the Coroners Act 2008*

I, K. M. W. PARKINSON, Coroner having investigated the death of SAMANTHA KILLEN
without holding an inquest:

find that the identity of the deceased was SAMANTHA JANE KILLEN

born on 29 September 1972

and the death occurred on 17 April 2009

at Kokoda Track, Papua New Guinea

from:

1a. HYPONATRAEMIA

Pursuant to Section 67(2) of the **Coroners Act 2008**, I make findings with respect to **the following circumstances:**

1. Ms Samantha Jane Killen was born on 29 September 1972 and was 36 years of age at the time of her death. Ms Killen resided with her husband and two young children.
2. Senior Constable Kelly Ramsay of Victoria Police Coronial Support Unit, provided a brief to the Coroner setting out police investigations, including information she obtained from Papua New Guinea authorities as to their investigations. In addition, the Coroner has obtained assistance from expert medical practitioners and consulted with a senior forensic pathologist in relation to this matter. I have drawn on all of that material as to the factual matters in this case.
3. Ms Killen left Australia on 15 April 2009, to undertake the Kokoda Track hike. She had joined an expedition being conducted by Niugini Adventure Tours. Ms Killen was travelling with her father, Mr Gregory Radford, her brother, Mr Grant Radford and a family friend, Mr Peter Elliot. She is reported to have been excited at the prospect of the trip and undaunted by the prospect of the physical and emotional challenges associated with such an endeavour.
4. Ms Killen is reported to have been in good health prior to leaving Australia and commencing the hike and had been involved in exercise preparation since October 2008 for the demanding

expedition. She had tailored her training to include endurance and other fitness activities. She attended the gym four times a week, walked an hour each night, with boots and backpack as the trip came closer. Her General Medical Practitioner, Dr A. Mark Johnson reported her as fit to undertake the walk.

5. The journey commenced on 16 April 2008, at the start of the track. The first day consisted of 8 hours trekking and Samantha and her father arrived at the camp after dark. Nothing out of the ordinary had occurred that day.

6. On the second day, they walked for five hours of trekking before lunch. The group stopped for lunch at a location known as Oki Creek, where Samantha sat in the water to, as she described, "refresh herself".

7. After lunch the group embarked upon a two hour steep climb. Samantha is reported to have taken her own pace. She is said to have commented on the amount of drinks she was requiring. Mr Radford described their exertion level as not being above what they had experienced when training for the trek. They stopped for a rest every 30 to 40 minutes. Samantha's progress slowed and she was having difficulty keeping up with the rest of the group. Her father remained with her and encouraged her to rest and to moderate her pace. She was then consuming what appeared to him to be normal amounts of fluid and he encouraged her to take small frequent sips of fluid. Samantha and her father were conscious of the need to remain well hydrated.

8. At approximately 3.30pm on 17 April 2009, Samantha became disoriented and confused and shortly after commenced fitting and lost consciousness. The party had reached a point known as Station 88. Mr Radford described:

"Samantha seemed disorientated so we took her pack off her and sat her down to have a rest and get some more water into her. After a short while she seemed to start hallucinating and said to me "Dad stop doing that, stop doing that", when I was standing opposite her doing nothing. We continued trying to get fluids into her but she threw up everything. She was sitting being supported by a porter when she seemed to go to sleep, but she was actually unconscious, as we could not wake her. We continued to cool her down by pouring water on her but she stayed unaware and after about thirty minutes she started convulsing .."

9. Notification was made to authorities that there was a medical emergency, however poor weather and light prevented the emergency evacuation helicopter from reaching the group or airlifting Samantha out that evening. At approximately 9.00pm, Samantha went into cardiac arrest. Despite intense resuscitation efforts being undertaken by her father and brother, Samantha died at approximately 9.10pm on 17 April 2009.

10. Samantha's body was repatriated to Australia and an autopsy was conducted by Dr Matthew Lynch, Senior Forensic Pathologist of the Victorian Institute of Forensic Medicine. Dr Lynch reported that the cause of death was unascertained.

"In my view the cause of death is most appropriately considered "undetermined" following post mortem. At autopsy there was no evidence of any specific pathological process which could be invoked as the cause of Ms Killen's death. Toxicological analysis detected paracetamol but no other drugs or poisons. Post mortem biochemistry revealed a variety of abnormalities. The creatinine and urea were elevated which is seen in cases of renal impairment and/or dehydration however the electrolyte profile is certainly not classical for dehydration in that the sodium and chloride levels were low (which generally occurs as a normal post mortem phenomenon). Moreover post mortem biochemistry needs to be interpreted with caution due to the confounding variable of artefact. A serum tryptase was elevated at 88.2ug/L. Whilst such elevation can occur in a setting of anaphylaxis, spurious elevations also occur (in the absence of any acute allergic reaction) and thus in the absence of a good historical exposure to a specific allergen I would be reluctant to invoke anaphylaxis as a contributing factor purely on the basis of an elevated post mortem tryptase."

11. He further commented:

"... there are a number of possible explanations for sudden unexpected death in a young person and the so called negative autopsy. These include various disorders of the cardiac conduction system such as Long QT syndrome, Brugada syndrome, WPW and CPVT (catecholaminergic polymorphous ventricular tachycardia). Various metabolic and/or biochemical derangements are also notoriously difficult to confirm at autopsy."

12. Dr Lynch reported that there were no obvious injuries, nor apparent natural disease, which may have caused or contributed to death and the toxicological analysis did not reveal the presence of any drugs of the type analysed.

13. Dr Lynch commented upon the possibility of hyponatraemia being the cause of Ms Killen's death. Hyponatraemia is a condition arising from low serum sodium. It is often associated with excess hydration leading to a diminution or imbalance of serum electrolytes and has been suspected as being associated with unexplained sudden death in otherwise fit persons engaging in extreme or arduous activity or sports.

14. Dr Lynch was provided with information from a medical practitioner who had recently trekked the Kokoda Track and had rendered medical assistance to a gravely ill Australian trekker. The patient survived but was noted to be severely hyponatraemic (low serum sodium). The doctor raised the possibility that such a mechanism may have contributed to Ms Killen's death. Dr Lynch stated:

"With respect to this proposition I make the following comments. Hyponatraemia is impossible to diagnose at autopsy as the sodium levels in the vitreous humour tend to fall as a normal post mortem phenomenon and thus the identification of the "low" vitreous sodium is not evidence of ante mortem hyponatraemia. Notwithstanding the foregoing caveat, should there be objective evidence of excessive water intake in Ms Killen, the autopsy findings would be consistent with death being due to a cardiac arrhythmia in the setting of electrolyte derangement. Post mortem CT revealed cerebral oedema."

15. Dr Jane Canestra of the Victorian Department of Health assisted the coroner in her investigation and provided information as to clinical features of hyponatraemia and its presentation in cases of extreme or arduous activity or sports.
16. Research is currently being undertaken in relation to hyponatraemia on the Kokoda Track by researchers at the James Cook University. A member of this research team, Dr Sean Rothwell an emergency physician, also provided a report at the coroner's request. Dr Rothwell reported:

"Exercise-associated hyponatraemia (EAH) is defined as a plasma serum sodium concentration of less than 135 mmol/L, occurring either during or up to 24 hours after prolonged physical activity.

The primary cause of EAH is excess consumption of fluids. Other factors contributing to EAH include:

- a. Inappropriate secretion of antidiuretic hormone during exercise;*
- b. Sodium loss from sweating may play a minor role.*

Recognised risk factors for developing EAH include:

- a. Excessive drinking behaviour;*
- b. Weight gain during exercise;*
- c. Female sex;*
- d. Low body weight;*
- e. Slow running or performance pace;*
- f. Event inexperience;*
- g. Non-steroidal anti inflammatory agents;*
- h. >4 hours exercise duration;*
- i. Unusually hot environmental conditions;*
- j. Extreme cold temperatures.*

Signs and symptoms of EAH include:

- a. Early, non-specific symptoms such as bloating, puffiness, headache, nausea and vomiting;*
- b. As the severity of EAH progresses, more serious signs and symptoms develop as a result of;*
 - a. Cerebral oedema - ataxia, agitation, confusion, delirium, obtundation, seizures, coma and death;*
 - b. Pulmonary oedema - respiratory distress.*

EAH is arguably the most important medical complication of prolonged endurance activity.

EAH has been documented in trekkers in the Grand Canyon and on the Kokoda Trail.

- a. The only published case of hyponatraemia on the Kokoda Trail occurred in 2006;*
- b. A second case of severe life-threatening EAH occurred on the Kokoda Trail in August 2008, resulting in helicopter evacuation of the trekker to a nearby US Navy ship. It is my understanding that Dr Ian Balsom cared for this trekker prior to her evacuation.*

Although there is no formal registry of evacuated Kokoda trekkers, I believe that the two abovementioned cases are the sickest trekkers who managed to survive. That is, the two sickest trekkers with a confirmed diagnosis both had EAH.

To my knowledge, there have been six unexplained deaths in trekkers on the Kokoda Trail.

- a. One in 2006;*
- b. One in 2008;*
- c. Four in 2009, including Samantha Killen.*

In April 2010, myself and 5 co-investigators conducted a study into the prevalence of hyponatraemia in Kokoda trekkers. The investigators were divided into two teams. One team trekked into Isurava from Kokoda and the other trekked into Ioribaiwa Village from Owers Corner. At the villages, the investigators performed blood tests on the passing trekkers from April 16 - 20, 2010. These locations were chosen because this is the first difficult day of the trek and is the point where medical emergencies reach their peak. For instance, it is around this time period that four of the six deaths and both documented cases of EAH have occurred. Samantha Killen would have passed through Ioribaiwa Village around mid-morning of the day she died.

- a. This study is yet to be published;*
- b. In general terms, of the 191 trekkers tested, three (1.57%) were found to have mild hyponatraemia;*
- c. In the group with a normal serum sodium, the median estimated fluid intake for the day of testing was 3.3 litres and for the previous day was 3.6 litres;*
- d. In the three trekkers with a low serum sodium, the median estimated fluid intake for the day of testing was 6 litres and for the previous day was 5.8 litres;*
- e. All three trekkers with hyponatraemia were retested after a few hours of fluid restriction (the treatment for mild EAH) and their sodium levels had returned to normal.*

Subsequent to our study findings, our recommendations to trekkers and trekking companies are similar to the current recommendations in the endurance sporting community.

- a. The best way to reduce the risk of EAH is to drink only when you are thirsty;*
- b. These recommendations have been made to trekking companies via the Kokoda Track Authority."*

17. Having reviewed the clinical and autopsy information in relation to Ms Killen, Dr Rothwell commented:

"Samantha exhibited a number of signs and symptoms of severe EAH (Exercise associated Hyponatraemia) namely Ataxia (unsteadiness) agitation, confusion, delirium, vomiting, obtundation seizure, respiratory distress, coma leading to death."

18. Dr Rothwell's opinion was that the autopsy findings were consistent with severe hyponatraemia, with death due to a cardiac arrhythmia in the setting of electrolyte derangement. He noted there was evidence of cerebral oedema on post mortem CT Scan and pulmonary oedema on autopsy. Dr Rothwell concluded that in his opinion, exercise associated hyponatraemia was the likely cause of Samantha's death.

19. Dr Lynch was asked by the coroner to review his finding in the context of the information which had been received from Dr Rothwell. He has confirmed his initial advice that should there be objective evidence of excessive water intake in Ms Killen, the autopsy findings would be consistent with death being due to a cardiac arrhythmia in the setting of electrolyte derangement. Post mortem CT revealed cerebral oedema and pulmonary oedema was noted by Dr Lynch at autopsy.

20. Dr Lynch in his supplementary report dated 20 December 2011 stated:

"In my original report I considered the cause of death to be undetermined. I was provided with an opinion from an anaesthetist Dr Ian Balsom to the effect that hyponatraemia may have been a contributing factor and I concluded my autopsy findings would be consistent with such a mechanism. I have also been made aware of a report from a Dr Rothwell indicating a view that the likely cause of death was in fact exercise associated hyponatraemia (EAH) in the setting of excessive water consumption. I would reiterate that my autopsy findings are consistent with such a cause of death with the mechanism of death likely to have been a cardiac arrhythmia."

21. There were also a number of factors in Dr Rothwell's report which he reported were relevant to the development of exercise acquired hyponatraemia, one of which included excessive fluid consumption.

22. I have been assisted by the reports of the expert witnesses in this case. The difficulty in this case is that, unlike in the research conducted on the trail by Dr Rothwell and his colleagues, there are no reliable ante mortem samples or records, which would evidence hyponatraemia. Nor is there definitive evidence of the amount of fluid consumed by Ms Killen, the excessive consumption of which was described by Dr Lynch as being necessary to enable such a conclusion to be drawn. There is however evidence that Samantha herself had commented upon how much and how frequently she was drinking.

23. I am required to make a finding as to the cause of death on balance of probabilities. The medical experts agree that exercise acquired hyponatraemia is a possible cause of Ms Killen's death. The indicators of exercise acquired hyponatraemia which have been identified by Dr Rothwell and which on the evidence before me were present in Ms Killen, included unsteadiness, agitation, confusion, delirium, vomiting, seizure and respiratory distress.
24. The risk factors for exercise acquired hyponatraemia described by Dr Rothwell and which I am satisfied were attributable to Ms Killen, include being of the female sex, event inexperience, greater than 4 hours exercise duration, unusually hot environmental conditions and possible excessive drinking behaviour. The forensic pathologist excluded any identifiable natural disease or any injury as causing or contributing to her death. Having regard to these factors, I am satisfied on balance that the cause of death was exercise acquired hyponatraemia and that the mechanism of death was cardiac arrhythmia in a setting of electrolyte derangement.
25. Having considered all of the available evidence, I find that Ms Samantha Killen died on 17 April 2009, at the Kokoda Track, Papua New Guinea and that the cause of her death was exercise acquired hyponatraemia and that the mechanism of death was cardiac arrhythmia in a setting of electrolyte derangement.

COMMENTS:

Pursuant to Section 67(3) of the **Coroners Act 2008**, I make the following comment(s) connected with the death:

1. There is sufficient evidence before me to warrant a recommendation that those authorities engaged in supervising, overseeing or promoting trekking at the Kokoda Track (and indeed any other high intensity and endurance event), provide information to participants as to the need to ensure appropriate hydration and acclimatisation.
2. The nature of trekking a location such as the Kokoda Track it involves extreme physical exertion and the inherent danger resulting from isolation and remoteness. The track is also subject to extreme turns of weather and low cloud cover, which may, as in this case result in emergency medical treatment or evacuation being unavailable.
3. Trekkers are subject to fitness level disclosure, health checks prior to commencing and the documentation provided by the tour operators appears to disclose the rigours and risks of the journey. However, it may be that the level or type of risk is misunderstood. Because many people, including high profile media personalities, have undertaken the journey in recent years, there is a risk of people not appreciating the reality of the physical task they will be undertaking. This combined with a lack of detailed information as to the necessity to balance fluid intake and to ensure appropriate hydration and acclimatisation may result in death or injury.

4. I have been assisted in this inquiry by investigations made by the Coroners Court of Victoria Prevention Unit. I am advised that there have been six deaths occur on the trail between 2001 and 2009. Some of those deaths are recorded as from cardiac related causes. Information obtained from media reports noted that the number of people attempting the walk have increased from around one hundred in 2001 to nearly six thousand in 2009.¹
5. I am further advised that the Kokoda Track Authority ("KTA") is a Papua New Guinean Special Purpose Authority and a joint initiative with the Australian Government. The KTA is commissioned to develop and maintain a tourism industry with tourism providers, help the local communities, collect and manage trekking fees and permits and to oversee and regulate the conduct of tour operators,²
6. The KTA has introduced a system of Commercial Operations Licences (COL) for any business being operated on the Kokoda Track Corridor. This licensing currently applies to all Kokoda Track tour operators. Trek permits are required by Licensed Tour Operators (LTO) and individuals who are not operating a commercial business who intend to use the Kokoda Track. This licensing system was created to set minimum standards for the Kokoda tourism industry.

Kokoda Track Safety Package

7. The Papua New Guinean and Australian governments have jointly funded an initiative to develop a Kokoda Track Safety Package (KTSP), which includes a number of projects to address infrastructure and safety issues along the Kokoda Track. Mr Brian Boon, Project Manager, advised that information kits are being developed for prospective trekkers as part of the health and safety initiative of the KTSP. He advised that the information kits will include advice on how trekkers can better prepare themselves for the journey; and information regarding fluid intake and quantity. Mr Boon advised that the KTA was endeavoring to provide all information for trekkers in one document.

Acclimatisation and trekker safety

8. Whilst there is a large volume of information available to trekkers in regards to developing adequate physical fitness before walking the Kokoda Track, the issue of acclimatisation to this remote and demanding terrain also requires consideration.
9. The need to acclimatise before undertaking exercise in hot, humid conditions has long been understood and is now an increasing focus of the sports medicine community. Acclimatisation produces physiological changes to the body to optimise performance in hot, humid conditions, such as improvements to sweating and cooling; electrolyte balances and reduces stress on the body.

¹ <http://www.sbs.com.au/news/article/1104637/at-a-glance-australian-deaths-on-kokoda-track>

² http://kokodatrackauthority.org/Kokoda-Track-Authority/About-the-Kokoda-Track-Authority_IDL=1_IDT=1256_ID=5665_.html

10. Sports Medicine Australia recommend that a period of acclimatisation should be undertaken before exercising in hot and humid conditions, especially if travelling from cold/temperate climates.³
11. Those considering walking the Kokoda Track should obtain the advice of their medical practitioner and engage the advice of sports scientists, or other suitably qualified professionals, to develop an appropriate exercise plan with an acclimatisation component included immediately prior to departure.

RECOMMENDATIONS:

Pursuant to Section 72(2) of the Coroners Act 2008, I make the following recommendation(s) connected with the death:

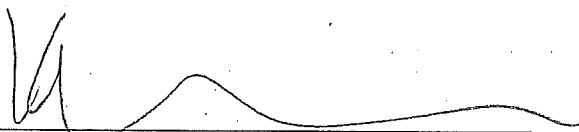
1. That the Department of Sustainability, Environment, Water, Population and Communities (Australia) in co-operation with the Papua New Guinea Department of Environment and Conservation collaborate on the development of physical preparation guidelines for prospective Kokoda Track trekkers, including advice relating to the importance of acclimatisation, the nature and risk of hyponatraemia in addition to that of dehydration.
2. That those guidelines be provided to all prospective Kokoda Track trekkers through licensed tour operators, and be published on the Department of Foreign Affairs and Trade Travellers advice website.

Pursuant to rule 64(3) of the Coroners Court Rules 2009, I further direct that a copy of this finding be published on the Coroners Court of Victoria Website.

I direct that a copy of this finding be provided to the following:

The Family; the City Coroner Waigani, PNG; the interested parties and to the Secretary, Department of Sustainability, Environment, Water, Population and Communities (Australia); The Secretary, Papua New Guinea Department of Environment and Conservation; The Chief Executive Officer, Kokoda Track Authority; The Coroners Office Papua New Guinea; Dr Jane Canestra, Department of Health Victoria; Dr Shaun Rothwell, Emergency Physician, Royal Brisbane and Royal Women's Hospital Brisbane; and to Mr D Simpson, Consular Operations Branch- Department of Foreign Affairs and Trade.

Signature:



K. M. W. PARKINSON
CORONER
6 February 2012

³ <http://sma.org.au/wp-content/uploads/2009/05/hot-weather-guidelines-web-download-doc-2007.pdf>