Intentional self-inflicted and peer-inflicted aerosol skin injuries called 'frosties'

Cohort series and systematic literature review

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Background and objectives
'Frosties' are deliberate cold skin burns caused by an aerosol device. The aim of this article was to examine our own cohort, and those previously published, to identify the key features of patients presenting with frosties and inform appropriate early clinical interventions.

Method
We compared cases in our dataset that occurred between 1 January 2013 and 30 June 2017 with those reported in the literature, focusing on seven domains: sex, age at injury, days to presentation, first aid, depth of injury and outcome.

Results
The median patient age was 13 years; 70.5% were female. Adequate first aid was not reported in any patient. Where recorded, the median time to presentation to a health service was six days. Where severity of injury was recorded, 13 of 37 cases (35.1%) were full thickness, and 10 patients received a split thickness skin graft. Two subgroups were identified: cluster injuries and psychological distress.

Discussion
Cluster injuries occur as the result of a mutual 'test of courage'. Solo injuries may point to underlying psychological distress. Frosties frequently result in significant burn injuries and often require skin grafting. The severity of frosties is underappreciated and, as a consequence, treatment, through first aid or presentation to a health service, is delayed or absent. General practitioners should be familiar with the appearance of frosties in order to identify them in unrelated consultations.

COLD AEROSOL BURNS ('frosties') are self-inflicted or peer-inflicted injuries sustained from the spraying of aerosol onto the skin. A frostbite injury occurs because of subsequent freezing of the tissues, commencing at approximately −2°C to −10°C. These injuries appear to occur predominantly in adolescents.[1] Concerningly, despite short exposure periods, these injuries are often severe. Reports have noted that surface temperature decreases to −40°C after a 20-second aerosol spray (propane–butane propellant) at distances of up to 15 cm.[2] The motivation leading to this activity is thought to be related to a peer-based 'test of courage', or 'dare', coupled with the easy promotion and propagation of such events through social media.[3] Despite cautionary reports in the traditional news media highlighting the short-term and long-term sequelae of frosties, the message regarding potential serious harm is still not fully appreciated.[4,5]

This study was conducted at the Pegg Leditschke Children's Burns Centre (PLCBC), the largest of three paediatric burns units servicing Queensland and Northern New South Wales, Australia (population about five million). The PLCBC sees approximately 1000 new burns annually in children aged 0–16 years, as well as treating quaternary referrals from the other two units in Townsville and the Gold Coast.

The purpose of this study was to draw on the PLCBC resources to identify a cohort of patients with frosties and compare their presentations and outcomes to those published in the broader literature. In this way we hoped to test the correlation of expected qualitative observations, garnered from the published literature, with our own large pool of data.

Methods

Frosties that occurred from the commencement of our burns centre database (1 January 2013) to 30 June 2017 were identified. The database provides information on the nature of the injury, its treatment and outcomes. These data were further augmented by review of clinical and operative records. In cases in which inadequate documentation was identified, an interview with the primary treating surgeon was conducted in order to obtain as full a record as possible. As is standard protocol within our unit, parental consent to use information for research was obtained prior to patient inclusion in the database. Human research ethics approval was obtained for this study (approval number HREC/15/QRCH/139).

A review of the literature was then conducted to identify other cases that could be compared with this case series. Medline, Cumulative Index to Nursing & Allied Health Literature and EMBASE were searched, with no limits on language or year of publication. An example of the search strategy for Medline is shown in Figure 1. The bibliographies of all retrieved manuscripts were searched to identify other potential cases.

The PLCBC dataset was then compared against the extant cases described in the articles that had been identified during our literature review. This was conducted over seven domains: sex, age at injury, days to presentation, cluster association, first aid, depth of injury and outcome. In domains with limited data in the broader

literature, we analysed only those cases in which the domain was addressed by the respective authors.

Ethics

Human Research Ethics Approval was obtained for this study (approval number HREC/15/QRCH/139).

Results

Our dataset included 11 patients (Table 1). In the broader literature, a further 45 cases were identified in 19 articles (Table 2). There were no statistically significant differences between our series and the published literature, so all 56 cases have been analysed as a single cohort.

The median age was 13 years, with an age range of 8–45 years. In all reports in which sex was noted, females predominated (24 of 34 cases; 70.5%). All injuries were below the elbow (volar forearm, back of the hand) or below the knee (ankles, shins).

Within our series, none of the reported injuries were accidental and there were no adult witnesses in any of the cases. In the broader cohort, there was only one adult patient described (45 years of age). This adult tried the technique after not believing a child's explanation for their own injury.

In nine of the 11 patients in our local series, first aid was not applied at all. With the exception of the cases reported on by Stefanutti et al and Tan et al, the rate of first aid application was not mentioned in the broader literature.[1,6] Stefanutti et al found first aid application to be universally inadequate in their series.[1] Tan et al noted that first aid was applied by the patient in their case report but did not comment on its adequacy.[6]

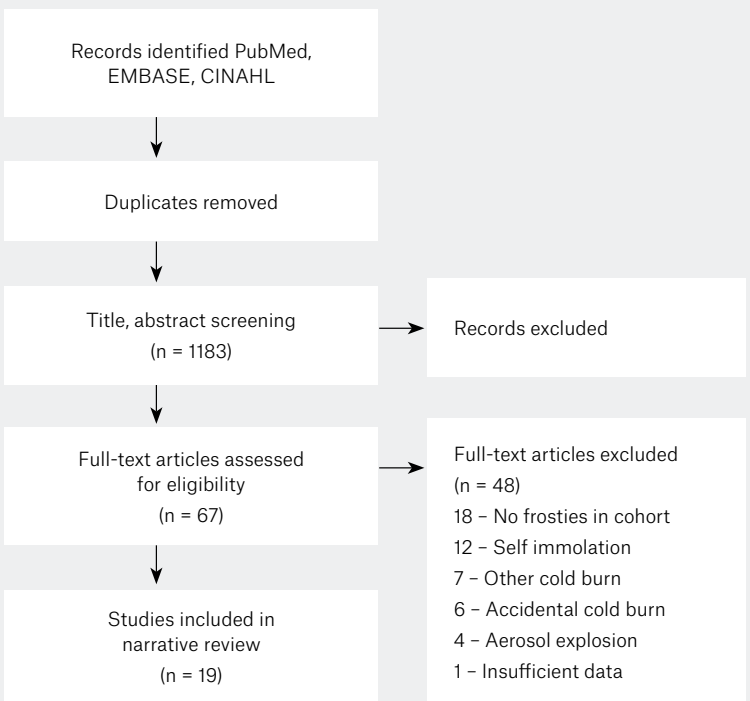
There was a universal trend of delayed presentation following a frostie injury. Five patients (15.2%) presented to a health service for other reasons and their frosties were discovered incidentally. In 27 cases in which time to presentation was noted, the median number of days to presentation was six, with only two cases (7.4%) presenting on the day of injury (one of which was incidentally discovered). The latest presentation was on day 32 post-injury.

In cases in which the severity of injury was recorded, 13 of 37 cases (35.1%) were full-thickness injuries. Ten patients received a split-thickness skin graft (STSG). Days to epithelialisation ranged from five days to 69 days in our local series. This was not recorded in any previously published case.

Clusters were relatively common. In our local series, three patients sustained their injuries as part of a group of like-minded peers with similar injuries. Not all adolescents in each cluster presented to the PLCBC, despite attempts to contact them. In the broader cohort, there were a further two clusters of two patients each.

Discussion

Risk-taking behaviour in adolescents is well documented and seen by



Example search strategy (PubMed)

#1 frosting[tiab] OR frosty[tiab] OR frostie[tiab]
#2 burn[tiab] OR burns[tiab]
#3 burns[MeSH]
#4 frostbite[tiab] OR cryogenic burn[tiab] OR cold burns[tiab] OR cold burn[tiab]
#5 "frostbite/chemically induced"[MeSH] OR "cold temperature/adverse effects"[MeSH]
#6 #1 OR #2 OR #3 OR #4 OR #5
#7 "self-injurious behavior"[MeSH]
#8 self harm[tiab] OR self inflicted[tiab]
#9 #7 OR #8
#10 "aerosols"[MeSH] OR "aerosol propellants"[MeSH]
#11 aerosols[tiab] OR aerosol[tiab]
#12 "nebulizers and vaporizers"[MeSH]
#13 deodorant*[tiab]
#14 #10 OR #11 OR #12 OR #13
#15 #6 AND #9
#16 #6 AND #14
#17 #15 OR #16

Figure 1. PRISMA diagram of search strategy

many authorities as an assertion of independence, coupled with a belief that no harm will befall the individual. Particular behaviours come in and out of fashion within peer groups over time; branding with a heated cigarette lighter ('smilies'), drug taking, extreme selfies, drink driving and frosties are all manifestations of this phenomenon. Notwithstanding the perennial nature of the issue, increased risk-taking is unsurprisingly correlated with increased injury rates and remains an ongoing social and medical concern.[7] There appears to be no protective effect from higher socioeconomic status.[7]

Frosties present a number of unique clinical challenges. First aid is infrequent, and patient presentation to an appropriate health facility is often late. This delay in applying first aid and receiving appropriate treatment was not clearly documented in the broader literature. Nonetheless it was clearly evident in our dataset, with all cases showing inadequate application of first aid and the majority also delaying their presentation to a health service. The reasons for this are likely to be multifactorial, and they may relate to the fact that frosties often appear to be inflicted in order to heighten a personal reputation or gain acceptance among a peer group. These factors actively prevent patients from seeking help early: a peer-inflicted and self-inflicted inertia compounded by the physiological effects of frosties, which are often associated with a localised anaesthetic effect that can lead to an initial underestimation of the injury.[1] Additionally, despite the short duration of exposure to the aerosol spray, the injury sustained is often severe (Figure 2). This is a reflection of the rapid drop in temperature precipitated by an aerosol spray to tissues at close proximity. Only three cases recorded superficial burns, and in 10 cases an STSG was required. These factors present a double blow to effective clinical management – a severe burn that is both poorly reported and underestimated by the patient.

Given the social factors described earlier, there is a possibility that our case series, and those cases that others have reported, are subject to significant selection bias. The 'aerosol challenge' is easily searchable on social media and shows predominantly adolescent individuals giving each other and/or themselves frosties. There does not appear to be the same bias towards females on social media as there is in reported cases. There are a number of possible reasons for this. The present review does not permit a definitive statement regarding this apparent sex discrepancy between social media and case reports. Males may be more likely to record and upload frosties but less likely to present than females. Alternatively, there may be an additional mechanism fomenting frosties in females and leading to their more common presentation.

In one of our cases, the reason for the injury was deliberate self-harm in the context of severe mental illness. This patient required involuntary psychiatric intervention. This case raises questions regarding whether frosties, particularly when inflicted alone, are a predictor of mental illness or simply an accessible and opportunistic form of harm for a vulnerable patient population. Similar concerns regarding the association of mental illness with this kind of injury have been raised previously.[8–10] Frosties may also be a significant marker for future harm,[8] with one study showing 80% of the frostie group performing further acts of self-harm.[10]

Table 1. Pegg Leditschke Children's Burns Centre case series dataset

Case	Sex	Age at injury	Days to presentation	Cluster	First aid	Depth of injury	Days to re-epithelialisation	Site of injury
1	M	14	15		No	FT (STSG)	NR	UL
2	F	14	5		No	SPT + DPT	15	UL
3	M	12	27		Yes, inadequate*	DPT (STSG)	47	LL
4	F	15	1	C1	No	SPT	26	UL
5	F	16	1	C1	No	DPT	39	LL
6	F	13	2		No	SPT	5	LL
7	F	13	12		No	DPT (STSG)	25	LL
8	F	13	13		No	SPT	69	LL
9	F	15	0 (incidental)		No	FT	Unknown (lost to F/U)	UL + LL
10	M	9	10 (incidental)		Yes, inadequate*	DPT	Unknown (lost to F/U)	UL
11	F	13	3	C2	No	FT (STSG)	Ongoing F/U	UL

**Adequate first aid is described as 20 minutes of warm (37–40°C) water until return of skin perfusion.*
C, cluster (with a number indicating a distinct instance in which the patient acted as a part of a group); DPT, deep partial thickness; F, female; FT, full thickness; F/U, follow up; LL, lower limb; M, male; NR, not recorded; SPT, superficial partial thickness; STSG, split thickness skin graft; UL, upper limb

Figure 2. Photographs of frosties

Serial photographs of a frostie from the Pegg Leditschke Children's Burns Centre cohort that underwent a split-thickness skin graft (STSG). Day 3 (A), day 14 (B; 7 days post-STSG with poor central engraftment, good peripheral take), day 21 (C; full epithelialisation). This patient was the 'victor' among four peers performing frosties on each other. The other three did not attend for treatment, despite our efforts to contact them. Also shown are photographs of self-inflicted frosties to left forearm and right inner shin (D) and infected untreated frostie (E).

There was significant underestimation of the injury sustained by the patients. This in itself suggests an important role for incidental observation and vigilance, particularly in a primary care setting, in order to identify and treat potentially underestimated moderate-to-severe injuries. Typically, sites chosen for frosties are visible, and an alert practitioner may detect these. This point is reinforced by the five patients we identified who were treated after incidental discovery of their injuries. In addition, it was not uncommon for clusters of people to inflict frosties on themselves or each other. These clusters presented to general practice either as a group to be treated or as an individual representing a pool of outpatients that did not present to a healthcare facility. This 'tip of the iceberg' phenomenon places the primary care physician in a unique position to identify, refer and support patients and their peers who have sustained these injuries. When seeing one case, it is important to ask if there might be others. The most recent patient in our series was one of a cluster of four individuals with frosties. Despite our repeated efforts, we were unable to encourage the other three to attend for treatment and thus they do not appear in this cohort (Figure 2).

Implications for general practice

- Frosties are not a common diagnosis, but this is now the third case series reported from Australian burns units, suggesting frosties have gained some traction in the adolescent population.[1,8]
- Despite the likely severity of frosties, patients are prone to underestimating the degree of their injuries and typically present late to a health service. Patients do not recognise frosties as burns, so first presentations are typically to general practitioners (GPs).
- Most frosties occur in sites readily visible to a GP. Incidental identification and recognition of the injury is an important 'catchment strategy' in the primary healthcare setting.
- When seeing a patient with a frostie, it is important to ask about others injured in a cluster event. This will ensure that as many cases as possible are identified and treated appropriately in a specialist burns service. It may also allow the associated schools to target an education campaign to prevent further events.
- For individual presentations, consideration should be given to the psychological health of the adolescent, as this may be an early sign of a developing pattern of self-harm.
- Although a small total body surface area is affected, the severity of the injury often requires advanced burn care, including grafting and scar management. Frosties should not be clinically dismissed without appropriate tertiary review.

An infographic summary of our study has been provided in Figure 3.

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Table 2. Cases identified in systematic review of published literature

Case	Sex	Age at injury	Days to presentation	Cluster	First aid	Depth of injury	Days to re-epithelialisation	Site of injury
(1991) Lacour & Le Coultre[2]	M	8	0		–	DPT (STSG)	–	UL
(2003) Akhtar & Majumder[11]	F	22	1		–	FT	–	UL
(2003) Camp, Ateaque & Dickson[12]	F	13	7	C3	–	–	–	UL
(2003) Camp, Ateaque & Dickson[12]	F	14	8	C3	–	–	–	UL + LL
(2004) Patel & Potter[13]	M	11	– (incidental)		–	–	–	UL
(2007) Connolly & Kennedy[14]	F	14	– (incidental)		NR	NR	–	UL
(2008) Tan, Anwar & Timmons[6]	F	13	10		Yes	FT (STSG)	–	UL
(2009) Arun, Jacob & Byrne[15]	M	13	4		NR	NR	–	UL
(2010) Stefanutti, Yee & Sparnon[1]	M	12	6		No	FT (STSG)	–	LL
(2010) Stefanutti, Yee & Sparnon[1]	F	11	28		No	SPT	–	UL
(2010) Stefanutti, Yee & Sparnon[1]	M	11	12		No	DPT	–	UL + LL
(2010) Stefanutti, Yee & Sparnon[1]	F	15	29		No	DPT (STSG)	–	LL
(2010) Stefanutti, Yee & Sparnon[1]	F	13	32		No	DPT (STSG)	–	UL
(2010) Stefanutti, Yee & Sparnon[1]	F	14	1		No	SPT	–	UL
(2010) Stefanutti, Yee & Sparnon[1]	F	11	21		No	FT (STSG)	–	LL
(2010) May et al[16]	F	14	1	C4	–	ST	–	UL
(2010) May et al[16]	–	45	1	C4	–	ST	–	UL
(2010) Kale & Shackley[17]	M	9	NR (incidental)		–	SPT	–	UL
(2014) Vlachodimitropoulou & Costello[18]	F	–	–		–	SPT	–	UL
(2014) Cubitt, Combellack & Drew[3]	–	–	–		–	SPT	–	UL
(2014) Cubitt, Combellack & Drew[3]	–	–	–		–	FT	–	UL
(2011) Bonniaud et al[19]	M	13	–		–	SPT	–	UL
(2012) Terrier-Lenglet et al[20]	F	14	–		–	ST	–	Bilateral UL
(2013) Henderson et al[9]	F	18	–		–	FT	–	Bilateral LL
(2013) Shah et al[21]	F	22	5		–	FT	–	UL
(2016) Nizamoglu et al[22]	–	–	–		–	FT	–	–
(2016) Nizamoglu et al[22]	–	–	–		–	FT	–	–
(2016) Nizamoglu et al[22]	–	–	–		–	FT	–	–
(2016) Nizamoglu et al[22]	–	–	–		–	PT	–	–
(2016) Nizamoglu et al[22]	–	–	–		–	PT	–	–
(2016) Nizamoglu et al[22]	–	–	–		–	PT	–	–
(2015) D'Cruz et al[8]	Nine self-inflicted aerosol injuries – nil further data recorded.							
(2017) Sayma et al[10]	Five self-inflicted aerosol injuries – nil further data recorded.							

C, cluster (with a number indicating a distinct instance in which the patient acted as a part of a group); DPT, deep partial thickness; F, female; FT, full thickness; LL, lower limb; M, male; NR, not recorded; PT, partial thickness; SPT, superficial partial thickness; ST, superficial thickness; STSG, split thickness skin graft; UL, upper limb

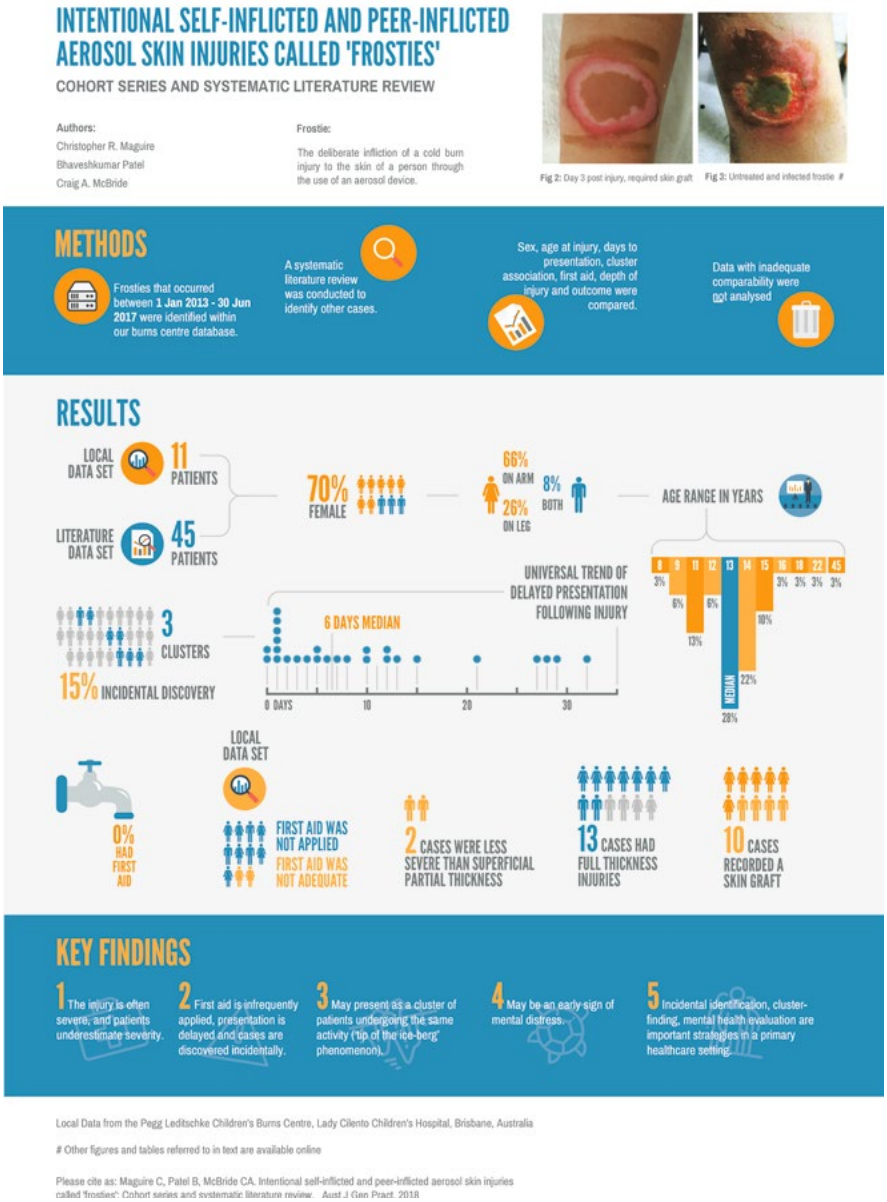

Figure 3. An infographic summary of the study

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