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‘All Four Engines Have Failed’: A qualitative study of the health impacts, reactions and behaviours of passengers and crew onboard flight BA009 which flew through a volcanic ash cloud in 1982

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ABSTRACT

This study investigated the experiences, health impacts and behaviours of passengers and crew onboard British Airways flight BA009 which flew through a volcanic ash cloud from Mount Galunggung, Indonesia, in 1982. In addition to secondary data sources, including a book published by one of the passengers, 18 semi-structured interviews were completed (14 passengers, 2 flight crew and 2 cabin crew) which were video recorded and transcribed verbatim. Data were analysed using reflexive thematic analysis to examine the experiences, behaviours, and actions of those onboard, and the health impacts of exposure to volcanic emissions. Our analysis identified five key themes which explain how people onboard flight BA009 responded: 1) Responsibility, 2) Airmanship and prior knowledge of aviation, 3) Upbringing and cultural background, 4) Faith and 5) Behaviour of the crew. Our study found few physical health impacts associated with the exposure to the ‘smoke’ and, despite individual cases of distress, there was no mass panic onboard the aircraft. Our findings highlight valuable information on passenger and crew behaviour in aviation crises, the risks of volcanic ash clouds to aviation, and have practical implications for aviation disaster management, planning and communication.

1. Introduction

On the evening of June 23, 1982, British Airways flight BA009 embarked on its journey from Heathrow airport in London, on a scheduled path toward India, Malaysia, Australia, and its final destination of Auckland, New Zealand. Cruising at 37,000 feet on its third leg of the journey from Malaysia to Perth, Australia, the Boeing 747, unknowingly to both passengers and crew, entered an ash cloud emanating from Indonesia’s Galunggung volcano [1]. Shortly after ‘smoke’ entered the cabin and flight deck, all four engines surged and flamed out [2]. After a 13-min and 23,000-foot gliding descent through the plume, several unsuccessful attempts to restart the engines, and plans to ditch in the ocean, the engines were re-started as the plane emerged beneath the ash cloud, only for one of them to fail again at around 13,000 feet altitude. Despite severe windshield abrasion resulting in poor visibility, the crew managed to land the plane safely at Jakarta airport and all onboard survived. ‘The Jakarta Incident’, as the event later became known, was an event unique in aviation history with a legacy that continues to resound today as the threat of volcanic eruptions to the aviation industry remains significant [3].

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According to international statistics, from 1953 until 2009, 129 aircraft encountered atmospheric concentrations of volcanic ash that were sufficiently dense to constitute a hazard to flight [4]. Following the eruption of Eyjafjallajökull volcano in Iceland in 2010, which resulted in ash reaching as far as continental Europe, widespread flight cancellations resulted in the largest shutdown in commercial aviation since World War II [5]. As well as the economic impact of the disruption, estimated to be \$5 billion, large numbers of people were affected, causing unease among the travelling public [2]. More recently, in December 2023, a volcanic eruption on the Reykjanes peninsula in Iceland prompted renewed interest in the environmental and health hazards posed to both local communities and the aviation industry [6].

While a global aviation strategy of ash avoidance has been devised [4,7], there is a dearth of published research on the health impacts, and responses and behaviours of those onboard aircraft during volcanic ash encounters, or other aviation crises. This is surprising given that air transportation is the world's largest industry, and one wholly dependent on people to ensure safety and security [8].

A growing body of literature has contributed a greater understanding of the health hazards and human factors associated with volcanic eruptions [9–12], as well as survivors' responses to other disasters including earthquakes, hurricanes, floods, and terror attacks [13–15]. However, there has been no investigation of the physical health impacts of exposure to volcanic emissions on aircraft, and little research into the psychological and behavioural impacts of aviation emergencies, despite recognition of the importance of understanding human factors in order to improve safety, security, and disaster preparedness [8]. Horwell et al. [16] have recently published the first review of the physiological, psychological, and behavioural impacts of occupants of aircraft which have encountered volcanic emissions, but they found little direct evidence in the literature.

The purpose of the present study is to generate this evidence by exploring the experiences of passengers and crew onboard flight BA009 in relation to the health impacts of exposure to volcanic emissions on flights, as well as the behavioural responses of passengers and crew during this particular, near-fatal aviation crisis. This study used qualitative methodology to capture memories of the crisis experience from both passengers and crew, a critical perspective that, in revealing the parts most salient to survivors, can shed light on the human factors associated with aviation disasters. In utilising this method, we acknowledge that disaster-related emotions and experiences are subject to recall bias and, collecting retrospective data forty years following the event, recall bias cannot wholly be excluded. The research questions that we aimed to address were.

1. What happened onboard flight BA009?
2. What were the acute physical and psychological health impacts?
3. What were the main influences/factors which shaped how passengers and crew behaved?
4. What were the long-term consequences of flight BA009?
5. What do narratives of BA009 tell us about the risks of volcanic eruptions to civil aviation?

Question 4 is addressed in a follow-up paper which investigates how the BA009 event impacted the occupants' lives in the 40 years after the incident.

Following the literature review and methods sections, we present a thematic analysis of the responses gathered from the qualitative interviews with participants.

2. Literature review

Relevant literature for this study is based on disaster mental health research, and the psychosocial aspects of passenger behaviour in emergencies and disasters. A review of the health hazards of inhaling of volcanic emissions in relation to aviation encounters can be found in Horwell et al. (2025) [16]. The following sections provide an overview of key findings and relevant concepts from the literature of benefit to this study.

Some of the first researchers to study passenger behaviour in an aviation context outlined four main factors that govern how people behave during, for instance, an evacuation [17]. The four aspects included: configurational factors (those governed by the shape and layout of the cabin i.e., number and location of exits), procedural factors (i.e., the actions of the crew, passenger prior knowledge of the cabin, and emergency signage), environmental factors (i.e., fire and the impact of smoke, heat or gases), and behavioural factors (aspects such as passengers response to the emergency and call to evacuate, and family or group interactions). Since these findings, several systematic studies based on findings drawn from accident reports have demonstrated the various human factors associated with aircraft incidents [18–23]. Until the early 2000s, the primary focus of the aviation psychology literature was the safety and the selection of aircrew [8]. Since then, however, researchers have widened their scope to include research on aspects of flying and passenger behaviour such as flying-related stress and anxiety [24], the legal aspects of passenger behaviour [25], air rage post 9/11 [26], hostage behaviour and aircraft hijacking [27], and the physiological effects of flying and consequences of the cabin environment [28]. Despite these vital additions to the literature, there have been few studies on passenger and crew behaviour in emergency and disaster settings, and therefore predicting behaviour during such events remains challenging [29].

In one of the few systematic studies on passenger behaviour, Galea [30] described how passenger and crew behaviour, rather than the extent of the accident, often determine survivability. Drawing on examples such as the Manchester Airport B737 fire of 1985, Galea [30] challenges the myth that when faced with an aviation emergency, the majority of passengers will panic and act irrationally and irresponsibly. The idea that 'mass panic' occurs in emergencies, in general, has largely been rejected by other studies too [31].

Chung [32] described the emotional consequences for both crew members and passengers associated with surviving an aircraft emergency and highlights the lessons learned from prior disasters to ensure appropriate support is offered to those affected. Heller [33]

described the range of psychological and psychiatric difficulties experienced by passengers onboard an aircraft, and the threat they may pose to fellow passengers' safety and comfort, while Thomas [34] addressed the issue of passenger attention to safety information and its relationship to survivability in the event of an incident or accident. In their review of the potential psychological impacts to occupants on aircraft which may encounter volcanic emissions, Horwell et al. [16] found no evidence of mass psychogenic behaviour or other negative group behaviours. While distress, on an individual level, is likely, there is also no evidence that this would spread to other passengers.

Other studies relevant to this research include studies from the field of disaster mental health research. Of particular relevance here is research on behavioural and psychological responses to disasters [35] as well as studies which have described the range of emotions reported by highly exposed survivors of disasters, ranging from fear and anxiety, to sorrow, grief, and guilt [13,36]. A recent study by Abu-Hamad et al. [15] on the immediate and evolving reactions of directly exposed survivors of the Oklahoma City bombing highlights the value of studying immediate thoughts, feelings, and actions of those exposed to disasters in order to aid responders, clinicians, and health authorities to anticipate emotional responses and tailor mental health interventions to particular needs or disaster events. Of relevance to the present study, Abu-Hamad et al. [15] observed feelings including (mental) numbness, disbelief, and shock, as well as behaviours such as helping others and responses which were shaped by a sense of responsibility towards others.

This study aimed to add to the limited published research on the health impacts, and responses and behaviours (e.g., the way or manner in which one conducts themselves) of those onboard an aircraft during a volcanic ash encounter, or other aviation crisis, as well as contributing to literature on emotional responses to disaster or traumatic events using a qualitative design, which we describe in the following section.

3. Methods

This section describes the method used, the value of qualitative research methods in disaster and emergency research, and describes research questions, data collection procedures and data analysis techniques. Most of the existing disaster literature is firmly planted in objective measures of psychopathology and quantitative methodology which lacks the raw experiences of survivors [15]. An effective approach to examining human behaviour, in particular the emotional processing and behavioural influences in disasters, is to analyse the retrospective narratives of survivors [13]. Qualitative disaster research has the potential to produce rich insights into how people, organisations, and communities face unprecedented events [37]. Utilising a narrative approach, our research aligns with disaster literature which utilises innovative and qualitative methods [14,15,29,38] in order to contribute knowledge of how passengers and crew respond to volcanic-aviation encounters to enhance knowledge of the implications of volcanic eruptions for the aviation industry, as well as human responses to aviation crises to aid aviation disaster management.

3.1. Procedures

Ethics approval was obtained from Durham University's Department of Earth Sciences ethical approval board (ES-2022-11-03T11_06_40-dgl0ch). Data for this study were collected via semi-structured interviews with passengers and crew who were onboard flight BA009 on the night of the incident. Interviewees were recruited via three routes: 1) The Galunggung Gliding Club, a peer support group established by survivors following the event; several interviewees were contacted directly by Captain Moody and his wife, who kept in contact with many of the passengers and crew. 2) A news article that was published in New Zealand (where many passengers were from) with the support of a journalist working for www.stuff.co.nz, calling for passengers to get in touch. 3) Social media (requests for contacts via Twitter/X posts, for example). Following contact with these participants, snowballing of further contacts took place. The inclusion criteria are having been a passenger or crew member onboard the flight and being over five years old at the time of

Table 1
Participant demographics.

Participant	Age in 1982	Gender	Passenger (P) or Crew (C)	Aircraft Location (cabin, row)
P1	21	M	P	Middle, left-hand side
P2	22	M	P	Back, middle
P3	19	F	P	Front
P4	21	F	P	Back, near smoking area
P5	26	F	P	Middle, right-hand side
P6	29	M	P	Back, middle
P7	21	F	P	Back, middle
P8	32	F	P	Middle, left-hand side
P9	33	M	P	Front, left-hand side
P10	25	F	P	Front, left-hand side
P11	35	F	P	Back, left-hand side
P12	11	M	P	Middle, right-hand side
P13	34	M	P	Middle, right-hand side
P14	21	M	P	Middle, left-hand side
P15	41	M	C	Flight deck – Captain
P16	30	M	C	All cabins
P17	32	M	C	Flight deck – First Officer
P18	29	F	C	Club class cabin

the incident. An exclusion criterion was not being able to participate for health reasons. In total, 20 passengers were contacted and 4 crew members. Of those, 14 passengers and 4 crew members were interviewed (Table 1). Some potential participants initially indicated that they would participate but then did not respond further. One had agreed to participate but then was too frail. Two other passengers were identified but were too elderly to participate, so were not contacted directly. Nine further passengers were identified but were confirmed as deceased by relatives or other participants. Therefore, our sample selection was biased by those whom we could identify, and were willing and able to participate. Semi-structured interviews of approximately 1 h in duration were conducted with passengers and crew with reflexive interview notes recorded by the interviewers. Interviews were video recorded using Zoom, with auto-transcription, and the transcriptions were then checked and corrected (by listening to the Zoom recordings) by a student at Durham University.

3.2. Sample

Once written informed consent was obtained (which included information on whether the participants wished to be anonymous or not; in the event, we decided that all participants will not be named in this paper except Captain Moody), 14 passengers, two cabin crew members and the Captain and First Officer were interviewed by the co-investigators (CH and IdT). The age of participants ranged from 52 to 82 (11–41 at the time of the incident). The average age of interviewees was around 70 and the majority are now retired. Most of the passengers and crew who were interviewed were from the UK, Australia, or New Zealand, which reflects the demographics of those onboard. Convenience sampling was used by choosing to interview those survivors who were still alive, responded to our calls for participants, and were willing to be interviewed about their experience for the study. As a result of our convenience sampling approach and choosing to interview remotely using Zoom, we were able to reach interviewees in the UK, Europe, Australia, and New Zealand. Information about the participants is provided in Table 1.

3.3. Interview data collection

The co-investigators (CH and IdT) were present in all interviews. Following exchanging introductions, and thanking interviewees for their support, the co-investigators typically began the interviews by asking a series of introductory questions, including: ‘Can you tell us how old you were on the flight?’; ‘Who were you travelling with?’; ‘What was the purpose of your trip?’ and ‘Can you remember where you were seated on the plane?’. The subsequent interview questions were formed in relation to four key themes: (a) physiological health impacts; (b) behaviours and sensory experiences; (c) psychological health impacts; and (d) other health consequences related to the flight experience (see Supplementary Material).

The interviews were concluded by asking about any other health impacts related to the experience or prominent memories that may not have been shared throughout the course of the interview. This allowed interviewees the opportunity to mention insightful

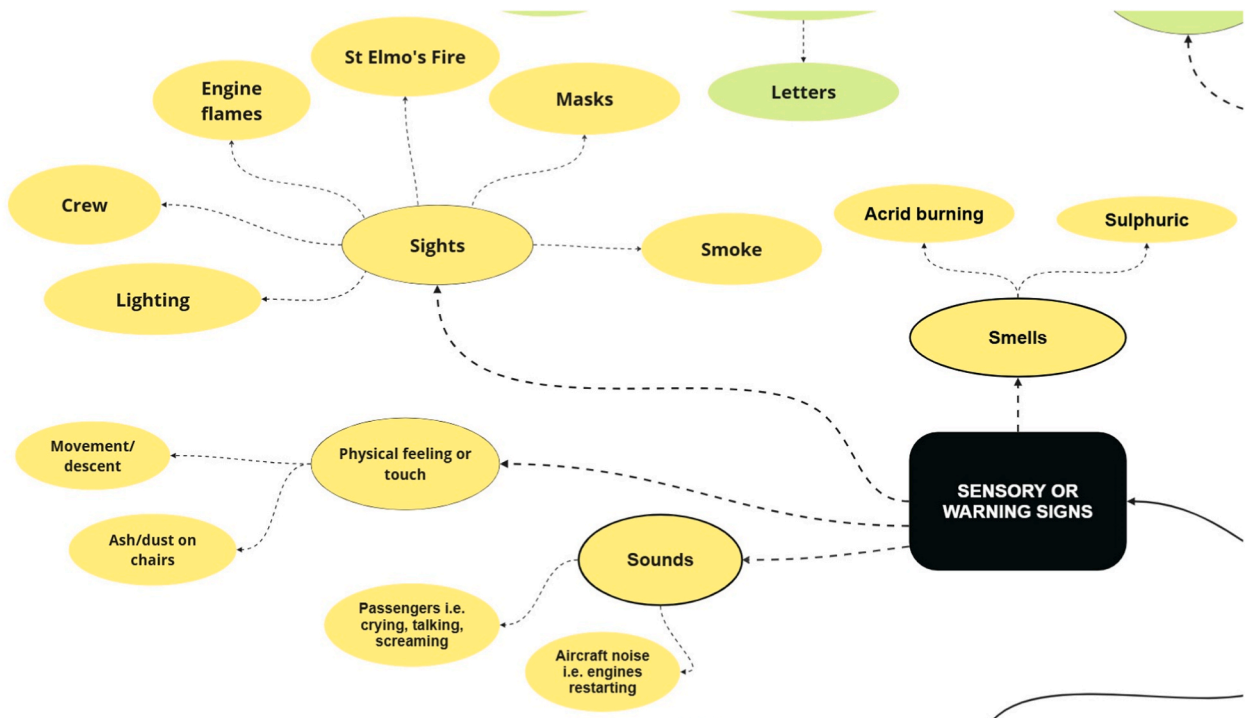


Fig. 1. Sub-section of the thematic map, showing sensory sign codes in yellow (see Supplementary Material for other sub-theme maps).

anecdotes and to reflect on the parts of the flight experience that were most salient to them.

To note, the crew were asked slightly different questions in order to prompt responses of relevance to their roles and responsibilities, including the technical details of the crisis and the timeline.

After the interview, participants were informed that they would be contacted within a week, with some follow-up information about the research process, which included links to psychological support should the interview experience have triggered traumatic memories. However, the participants were also informed that dreaming or thinking about past events was normal after recalling them in detail.

3.4. Interview data analysis

Interview transcripts were analysed by the first author (RM) following the principles of thematic analysis [39–41]. Thematic analysis allowed us to identify, analyse, and interpret patterns of meaning (themes), through a reflective, flexible, and iterative process. We conducted the analysis from a holistic, constructionist paradigm [37,42,43], which sets human behaviour in context and considers the role that sociocultural context plays in shaping our experiences, behaviours, and generation of knowledge. There was no pre-existing coding frame. Instead, codes were developed as the data were analysed. In this sense, the themes identified are strongly linked to the data themselves, meaning the results are data, rather than theoretically, driven. In addition, we chose to adopt a latent approach to the analysis in order to go beyond the semantic, surface-level of the data, to examine the underlying ideas, assumptions, and ideologies, that shape or inform the semantic content of the data [39].

The first author (RM) analysed the data using the six-phase approach as specified in Braun and Clarke [39,40], which involves the following steps: (a) becoming familiar with the data, (b) generating initial codes (assigning labels to sections of text), (c) searching for themes, (d) reviewing themes, (e) defining themes, and (f) writing up results. The next stage involved becoming immersed in the data through multiple readings of the transcripts to identify preliminary ideas. Following this initial step, RM began to code any interesting features of the data across the entire data set and collated data relevant to each code using qualitative analysis software NVivo 12 Pro (<https://lumivero.com/products/nvivo>).

Collated codes were then grouped into potential themes and presented in an initial thematic map created using Miro design software. Fig. 1 shows the sub-theme map for sensory signs; see Supplementary Material, Fig. S1 and S2 for sub-theme maps on influences and health impacts (final versions presented). The initial thematic map of interrelated themes and sub-themes was then presented by RM to the co-investigators who asked questions and made suggestions, helping to refine the names and contents of the themes and sub-themes. The discussions around the thematic map and the inclusion of the entire research team in these discussions [44] were an essential part of the data analysis process. These discussions helped to refine and improve the themes in relation to our research questions and configure our findings into two distinct areas: health impacts, behaviours, actions and emotions *during* the crisis, and *long-term* psychological consequences, support, and coping.

For the purpose of this paper, we were most interested in identifying aspects of the data related to the research questions on sensory experiences and impacts during the flight; these include the signs that alerted passengers to an emergency onboard the aircraft, and how these signs impacted upon health, behaviour, and emotions throughout the flight. Material relating to the questions regarding

Table 2

BA009 (Boeing 747-236B G-BDXH; call sign Speedbird 9; aircraft name ‘City of Edinburgh’) timeline.

Date	Time	Event
23 June 1982	20:17	BA009 departed London Heathrow airport (delayed from 18:40) with 248 passengers and 16 crew and travelled towards Auckland, New Zealand via Bombay, Kuala Lumpur (and expected to also stop in Perth and Melbourne).
24 June 1982	13:35	Plane flew over Jakarta airport. No hazardous conditions reported and weather radar was clear. Captain Moody left flight deck.
	13:45	Flying close to south coast of Java. Smoke noticed inside and ‘St Elmo’s fire’ outside. Captain Moody returned to flight deck, power in engines began to reduce.
	13:47	#4 engine surged, flamed out and engine fire checklist was initiated by Flight Engineer. Bucking motion from engine restart attempts.
	13:48	Total engine failure (37,000 ft). Mayday call made.
	13:51	28,000 ft. Captain planned descent to 12,000 ft.
	13:53	26,000 ft. Oxygen masks donned by flight deck crew due to low pressure (except the First Officer whose mask failed, requiring increased rate of descent to avoid incapacitation).
	13:54	15,000 ft. Passenger oxygen masks dropped and were donned. Captain made PA announcement informing passengers and crew about the issue. Cabin Service Officer called to flight deck and then informed cabin crew to expect emergency landing.
	13:57	~14,000 ft. Captain considered ocean ditching in the dark.
	13:58	~13,000 ft. Engine #4 restarted and rate of descent reduced. Engines #2–4 restarted, allowing some ascent, resulting in resumption of ‘St Elmo’s fire’ (re-entry into ash cloud).
	14:00	Captain made another PA announcement stating that they would be diverting to Jakarta airport. Engine #2 surged and was shut down and flight descended to 12,000 ft.
	14:18	During final descent, flight crew realised that the windshield was opaque.
	14:25	Flight BA009 touched down at Jakarta Halim airport.
	14:46	Flight BA009 arrived at the terminal at Jakarta Halim airport (after towing).

Timeline compiled from: Human Factor documentary ‘The Longest Twelve Minutes of Our Lives’ (<https://youtu.be/VALx4Vc4jgk>), Wikipedia (https://en.wikipedia.org/wiki/British_Airways_Flight_009), Betty Tootell’s book *All Four Engines Have Failed* and input from participant P17 (First Officer). Times in UTC (-7hr Jakarta time).

long-term psychological health impacts and coping will serve as the basis of a follow-up paper on psychological consequences of the event and how survivors coped in the years following its aftermath.

3.5. Secondary data

Secondary data were sourced for this study through internet searches, including for available television documentaries and news articles. Additional resources were also identified through discussions with participants in the interviews. A copy of Betty Tootell's book was purchased from an online retailer.

In order to supplement the qualitative interviews and gain a nuanced understanding of the data collected for this analysis of flight BA009, we draw on these additional data which include nine interview transcripts with passengers and crew, conducted in 2006 for the National Geographic Air Disasters documentary 'Falling from the Sky', with transcripts provided by the production company (see Acknowledgements). These interviews were thematically analysed by RM in the same way as our interview data.

To provide additional context, we also draw on a book of the event written by passenger Betty Tootell [45], titled *All Four Engines Have Failed: The True and Triumphant Story of Flight BA009 and the Jakarta Incident*. Betty Tootell had interviewed many passengers and crew in order to write the account of the event. We coded the book according to themes including sensory signs, thoughts, feelings and behaviours. We also used secondary data given to the team by interviewees including photographs, and information from crew logbooks and diary entries, written shortly after the incident.

We also provide a timeline of the event (Table 2), to enable readers to contextualise the participant data. The timeline was compiled from information from the First Officer's logbook, Betty Tootell's book, and from information available on Wikipedia (https://en.wikipedia.org/wiki/British_Airways_Flight_009), as well as a 'Human Factor' documentary: 'The Longest Twelve Minutes of Our Lives' which aired in 1986 (produced by Television South plc) and is available on the internet (<https://youtu.be/VALx4Vc4jgk>).

3.6. Participant involvement in this paper

Given that this paper discusses sensitive thoughts, feelings and behaviours of the passengers and crew onboard BA009, we wanted to ensure that we had correctly represented their memories and interpreted their feelings. We therefore sent a complete draft of this manuscript to the 18 interviewees for feedback. Nine interviewees responded and adjustments were duly made. For the most part, these related to the accuracy of the timeline (P17) but several interviewees commented that the paper had helped them realise that their own experiences were shared by others on board.

3.7. Data management

All data were stored in password protected online storage, accessible only to the researcher and co-investigators, in line with the data management plan. Consent forms were collected digitally and stored separately from anonymised participant data.

4. Results

The remainder of this paper examines the themes and sub-themes as revealed in the data analysis. The results from the qualitative analysis are organised into five sections. The first covers warning signs, which explain how passengers and crew identified an emergency. The second section covers physical health impacts which were experienced at the time of the incident. The third section covers thoughts and feelings, while the fourth section illustrates how passengers responded, demonstrated through behaviours and actions. The final section outlines some of the social and environmental influences which shaped how people onboard the aircraft behaved. The results are presented with key excerpts that illustrate how interviewees expressed the themes.

4.1. Warning signs

When asked about sensory experiences during the flight and other signs of a crisis, many interviewees indicated that, while the cause of the crisis was unknown, several key warning signs signalled an emergency. The key sensory signs noted by those onboard, included: the sight or smell of 'smoke' or dust settling in the cabin, the silence of the aircraft (because the engines had stopped), the feeling of sudden descent, 'bucking' as attempts were made to restart the engines, as well as visual sights such as flames emanating from the engines, oxygen masks, and a light phenomenon similar to St Elmo's fire.

4.1.1. Smoke

The first sign of an emergency for many onboard flight BA009 was the sight of 'smoke' or dust entering the cabin which intensified over time. Visually, interviewees' accounts describe the smoke as *misty*, *black*, *dense*, and *pretty thick*. Memories of the smell of the smoke varied depending on seating position in the cabin. While some interviewees recalled the smoke as odourless or having a *neutral* or *burning* smell, others such as Captain Eric Moody, recalled an *acrid*, *sulphurous* odour reminiscent of the London Underground. Initially, most of the passengers and crew believed the smoke was caused by cigarettes or cigar smoke which could be coming from the smoking area at the back of the plane. Believing this was the most likely explanation, there was not too much concern about the cause of the smoke, initially. However, as the smoke intensified, passenger's thoughts turned to other causes such as *burned* or *smouldering wires* or a *duct overheating issue*. One interviewee recalled the sight of the smoke resembling that of the days when people could smoke

in the cinema, with the overhead reading lights lit up like 'search lights cutting through' [P5]. Other interviewees recalled the smoke's 'dusty appearance' and how 'running your fingers on the surface, it would come up black' [P17]. Reading from their diary, written on the evening following the incident, one cabin crew member provided the following vivid account of the smoke:

My first indication of the problem was when I looked towards the rear of the aircraft and noticed it was very hazy in Zone E. It looked smoky, but we were later to find out that this was volcanic ash, causing an overall, dusty appearance ... The smoky smell had by this time hit me and, on reflection, I must admit I felt frightened for the first time. [P18]

4.1.2. 'St Elmo's fire'

A slightly more unusual sign recalled in the interviews, primarily by those in the flight deck, was the sight of a light phenomenon, which they thought was St Elmo's fire, on the windshield and wings of the aircraft. For the First Officer, the sight of the 'St Elmo's fire' on the windshield was the first indication of an emergency. Looking out from the flight deck, he saw what he described as 'tiny little pinpricks of light on the windshield' [P17]. Over a period of several minutes, the phenomenon grew in intensity until: 'the pinpricks of light got more and more numerous and intense until eventually the windshields in front of us were just two brilliant white sheets of light' [P17]. Captain Moody recalled seeing 'the most tremendous and beautiful display of St. Elmo's I'd ever seen', a sight that normally appears in white as a 'multitude of colours' that went from 'short lightning to longer lightning, dashing up and down the screen' like 'tracer bullets coming off the nose' of the aircraft [P15].¹ Further to the display witnessed by the crew on the windshield, passengers recalled a similar spectacle of white light as they looked out of the cabin toward the wings. As one passenger described:

I glanced over to the left where I had a clear view of the port wing and to my surprise it was covered in a brilliant white shimmering light which seemed to be clinging to the wing of the aircraft. I'd never seen anything like that before. [Passenger interviewed for 'Falling from the Sky', *National Geographic*, 2006].

Other passengers, and the crew, noticed a similar phenomenon in the engines:

I'd looked out on the right-hand side, and I could see number four engine which was lit up like there was a search light inside the engine shining out. It was like it was lit up from inside, you know. [P17]

4.1.3. Engine flames

Another sign which alluded to the aircraft being in danger was the sight of flames as the crew attempted to re-start the engines, a memory which evoked responses such as 'you know you're in trouble when you see flames' [P8]. A sense of what interviewees saw and how they felt is evident in the following excerpts:

My mother, I remember when she saw the flames outside, because we didn't know what was wrong, she said 'I don't think we need to see that dear', and she pulled the blind down, and I can remember myself turning to the left, when a lady, about two rows behind called out, 'We're on fire!' ... At the same time, I had my shoes off. I always take them off on a flight, and I remember moving my feet and thinking if the floor gets warm, I know it's imminent that flames will burst through. [P5]

[It was] best described perhaps as a fireball of very yellow fuel, igniting behind the engines. So, we could see out the left side of the aircraft - we're behind the wing - and we notice these kinds of sheets of flame like after-burner, kind of, which obviously we've never seen before. [P2]

The First Officer (P17) explained that the engine flames had occurred as a result of fuel being introduced into the engines which then ignited. However, stable combustion and engine start were not achieved, thereby creating the flames.

4.1.4. Oxygen masks

Following the sight of the smoke and the engine flames, passengers recalled further signs of an emergency, such as sudden darkness as the cabin lights went out, as well as oxygen masks falling from the overhead panels (at 14,000 feet; [P17]). One passenger stated: 'when the oxygen masks came down obviously that was not a good sign' [P9]. Another interviewee recalled:

And then the oxygen masks were deployed. That was a pretty significant commitment to the fact that the aircraft was in trouble and around that time the cabin crew were moving around carrying portable oxygen masks on their faces which they were holding up to their faces. [P2]

At 26,000 feet, the oxygen masks had earlier descended for the flight deck crew. For the First Officer (P17), the entire mask system (including tubes) fell from the ceiling, meaning he could not use the mask. This prompted the Captain to start a semi-emergency descent to reach a safe altitude where the First Officer would not become incapacitated. This procedure (using the speed break, to increase the rate of descent [P17]) would also have caused vibrations which would have been felt by the passengers.

¹ While the crew were unaware of the ash cloud, they later discovered the 'St Elmo's fire' was a result of the electrostatic discharge as ash encountered the aircraft. St Elmo's fire is actually a meteorological phenomenon of fluorescing plasma generated by ionization of air molecules. It is likely that the light on the wings and around/inside the engines was also electrostatic discharge from the ash.

4.1.5. Sounds

Another warning sign reported by interviewees related to auditory signs that the aircraft was in trouble. Aside from isolated screams and crying, nearly all interviewees recalled noticing the silence of the aircraft when all four engines had failed. Passengers also recalled hearing *grinding* and *banging* when attempts were made to re-start the engine. A sense of the auditory experiences encountered throughout the incident are exemplified in the following excerpts:

We became aware that the aircraft's engines had gone, either one by one, or one by two. I'm not sure of the sequence and then of course it was eerily silent. [P16]

I remember there being an eerie noise, you know, silence, which you don't get on a jumbo. It really was very eerie. Sort of like, you know, the wind whooshing by. [P18]

All of a sudden there was silence. Just a hush. There was, you know, you see, on movies when things like that happen, there's screaming, and goodness knows what else, but it was dead quiet. You could have heard a pin drop. [P7]

4.1.6. Movement

The final warning sign of an emergency onboard flight BA009 where various feelings of movement onboard the aircraft. Interviewees described *shaking*, *shuddering*, and *rattling* of the wings as well as the feeling of sudden descent as the aircraft glided 23,000 feet through the plume. Other passengers and crew explained:

At one time the aircraft developed a strange motion. It seemed to be climbing steeply and then diving down, that was the sensation we got, and a bucking action that was so violent that we felt it could break the aircraft up in the air. It was a little bit like climbing up the long slow climb in a roller coaster, pausing at the top, then diving down. [Passenger interviewed for 'Falling from the Sky', *National Geographic*, 2006]

I do remember at one stage trying to get my trolley to stow it, and I remember having to dig my heels in because we were going down quite steeply, to try and stop the trolley going too fast ... the trolley was taking me, and then somebody, I think it was [crew member] at the other end, got the trolley, and we got it away. [P18]

4.2. Physical health impacts

Our interviewees did not identify acute physical health impacts as a result of being exposed to volcanic emissions onboard flight BA009. As many people onboard the flight thought they were going to die, most reports of health complaints were psychosomatic in nature, including reports of feeling shaky, trembling, or short of breath, which were likely related to fear, as opposed to being caused by the 'smoke'.

My hands were shaking and my knees trembling. I admitted to [crew member] that I was scared too. We gripped each other's arm momentarily. A million things passed between us, and then we were off doing the job we, thankfully, were fully trained to do. [P18]

However, in *All Four Engines Have Failed* [45], Betty Tootell describes how, as the aircraft's downward speed increased, one of the passengers 'suffered a painful attack of angina pectoris' which required her to take medication for pain relief [p.78]. In addition, one of the crew members interviewed for the National Geographic documentary *Falling from the Sky* described how 'the acrid smoke was at the back of your throat, up your nose, in your eyes, and you're rubbing this, and your eyes are running'. Other physiological complaints identified in the National Geographic documentary transcripts included mild respiratory complaints (from an interview with a person who was a child at the time of the flight, referring to symptoms experienced by himself and his brother).

I had some mild asthma. My brother had it quite a bit more severe than I did. I just remember coughing and trying to get my breath because there was a lot of smoke in our area. [Passenger interviewed for 'Falling from the Sky', *National Geographic*, 2006].

In addition, there were two compelling accounts of long-term psychosomatic health complaints which were perceived to have been caused by the stress of the incident, including the Captain's hair turning white and a cabin crew member developing psoriasis, both within a few months following the incident. Although scant, there is evidence that acute stress leads to the hair greying [46] and that people with psoriasis believe that stress exacerbates the condition [47].

I went to bed one night and I woke up the next morning and I had a white patch here (gestures to front of head) a couple of months afterwards, and then it took a few months, weeks to go white all over. [P15]

Psoriasis. I never had it before '82. It started in about '83, started minor and then, whenever I'm stressed like now ... as you can see on my hands, and on my back. And yeah, I'm pretty certain it's related to the stress and is a direct result of the incident, that I contracted psoriasis. [P16]

4.3. Thoughts and feelings

Several thoughts and feelings in relation to the warning signs and an awareness of an emergency onboard the aircraft were described by participants. As passengers and crew attempted to make sense of the situation and understand the nature of the emergency, four main types of feelings occurred: *distress*, *calm*, *fatalism*, and *relief*.

4.3.1. Distress

Both passengers and crew described feeling fearful or anxious, however, only isolated incidences of extreme/observable distress seem to have occurred. An anecdote which featured in several accounts described a distressed woman who pleaded with the crew to 'hide her baby'. As one interviewee recalled, she said 'Can you hide my baby?' to which the cabin crew member responded, 'There's nothing to be afraid of, there's no need to hide anywhere, because we're all in the same place, and everything's going to be fine' [P16]. Another account of distress involved another female passenger who, upon becoming hysterical, received 'a slap in the face' from her husband. Besides these two examples, passengers and crew did not recall negative group behaviours throughout the incident. Most respondents described the futility of panic, as one interviewee stated: 'None of us panicked because we couldn't help ourselves. You only panic when you think you can save your soul somehow. But there was no way for us to do anything' [P8].

4.3.2. Calm

In light of the above, many responses to questions regarding thoughts, feelings and behaviours during the immediate crisis described an atmosphere more akin to calm acceptance onboard the aircraft. As one passenger stated:

You know if you're confronted with imminent bloody peril, it's amazing how calm you are ... I mean in the cabin there were people crying, people praying, but there was no sign of panic whatsoever. [P9]

For some, this came from a need to 'act decently' so as not panic others, (i.e., 'it seemed important to keep your end up and behave decently as we felt with certainty there's no way out of this, we're going to die' [passenger interview for 'Falling from the Sky', *National Geographic*, 2006]) while, for others, this sense of calm stemmed from a belief that the outcome was going to be fatal. For example, when asked how they felt after the Captain made an announcement that all four engines had failed, one passenger recalled: 'Remarkably calm. I sort of thought: well, there's two ways I can go. I can either go in sheer panic - and that's not good - or I could go calmly' [P4]. In other cases, such as for the crew, remaining calm and composed was vital to keeping passengers safe. For the youngest passenger interviewed for the study, who was eleven at the time of the incident, the calm composure of the crew remained a prominent memory of the event forty years on:

My recollection is that there was no great hysteria going on at all. People were really quiet in my part of the plane anyway. People were quite silent and calm. [...] I don't remember him panicking at all. I think he was just really quite professional looking back on it. And I guess yeah, you just got a sense that the crew knew what they were doing. [P13]

For many passengers, the sense of calm felt in the cabin was associated with feelings of vulnerability, helplessness, and lack of control:

I've never been too afraid of dying, but when you're sort of confronted with it, it's not a good thing. It's a bit like being in a hospital bed, the surgeon's just took the knife, and just, you know, you have to put your fate in someone else's hands, and you have to lie back and accept it. [P9]

These thoughts are also related to fatalism.

4.3.3. Fatalism

In response to questions about thoughts as the emergency developed, many interviewees described grappling with their fate and thoughts about how they were going to die. One survivor described:

We didn't talk about it. But we were definitely thinking there is no way out, here. I mean it was 9 o'clock. It was dark outside, you know, and we were in the middle of nowhere ... And my biggest fear was that we would crash into the ocean, and I would drown. And I saw myself like underwater with air bubbles going up and drowning. [P8]

As the flight deck made futile attempts to re-start the four engines, passengers described having little else to do but contemplate death as they sat through a 13-min, 23,000 foot descent through the plume:

Will we be burnt alive? Will we be choked by the smoke? Will the aircraft break up in the air and hurtle us out into space? (which was my biggest fear). Or will we come down in the sea and be eaten by sharks, alive, or will we crash into a mountain? Let's crash into a mountain quickly and get all this over. [Passenger interviewed for 'Falling from the Sky', *National Geographic*, 2006]

It felt like I was in a lift. And I thought the lift doors are going to open and I am going to see the answers to all things in life, if that makes sense. And that was how my head saw death ... we spend our lives in the lift and doors open, and we get out on different floors, and we live our lives. But this time, when the lift door opened, it was going to open to eternity, and I would know all the answers. [P5]

4.3.4. Relief

Lastly, participants reported feelings of relief. Initially, the sense of relief was reported in response to hearing one of the engines successfully re-starting. Relief was again reported upon hearing the Captain's second announcement that the plane would be diverting to Jakarta and, finally, people were relieved when the plane touched down safely on the runway. As one participant described:

Once we landed in Jakarta and the plane stopped, there was a moment of silence, and then, all cheering from the front to the back of the plane, and people were getting out their duty-free and sharing it. And, you know, the relief that we'd landed. [P7]

Others recalled feeling the plane had levelled out or the engines restarting which instilled a feeling of optimism that they might survive:

There was still a lot of people obviously upset but I think the general mood had improved and people were starting to feel as though there was some hope, that there was a way out of this. [Passenger interviewed for 'Falling from the Sky', *National Geographic*, 2006]

When that first engine re-ignited and started up, oh it was a great relief, oh it was a blessing. I thought, I know these engines, I know these 747s can fly on one engine, and that was just bliss for me to hear and then when the other one kicked in my heart lifted. I was walking on air. [Crew member interviewed for 'Falling from the Sky', *National Geographic*, 2006]

4.4. Actions, reactions, and behaviours

Passengers and crew responses to the crisis took the form of several actions, reactions, and behaviours. Due to the confined nature of the emergency, the vulnerability of passengers, and impossibility of escaping the danger, most behaviours were centred around practical considerations (i.e., changing or removing articles of clothing, searching for life jackets, or donning oxygen masks), as well as providing reassurance and assistance to others, and religious actions such as praying. In addition, a number of passengers coped by displaying behaviours such as humour or by distracting themselves from the potential outcome.

4.4.1. Attending to others

There was a strong sense of camaraderie in both passenger and crew accounts of the crisis, with many actions and behaviours driven by a sense of care and duty towards others. All passengers recalled the professionalism of the cabin crew who used both verbal and non-verbal communication to convey reassurance to passengers. As one of the cabin crew members described:

Once everybody was on oxygen, I ended up walking through the cabin. I would take my mask off and say, 'are you alright?' Put it back on. And they'd say, 'yes.' And I said, 'yes,' [puts thumb up] and they would go, 'yes.' So, in the end, I could walk through my cabin really, really quickly, and I could just go [thumbs up], and they would all go back to me [thumbs up]. And, when we had one of the meetings (Galunggung Gliding Club), one of the passengers came up to me and he said, 'I can't tell you how normal that made me feel - you going through, just going [thumbs up].' It was just a normal thing for me to do. [P18]

Another member of the cabin crew recalled acting on 'instinct' by taking a megaphone and communicating to passengers to remain calm and that 'everything is at hand' and was 'going to be fine' [P16]. Passengers likewise displayed acts of attending to others. There were several descriptions of attending to elderly relatives and younger children, as well as providing reassurance to other passengers in their vicinity, including trying to communicate with passengers who did not speak English. Additionally, several interviewees reported instinctively closing the blinds to protect others from seeing the engine flames.

4.4.2. Faith

There were numerous narratives which described actions and behaviours that were guided by the individual's faith, for example praying, as well as spiritual encounters or reconciliation with religious beliefs. Some interviewees described having a powerful sense that God was looking after them. For example, they recalled becoming preoccupied with their relationship with religion, while two respondents recalled an elderly religious woman who claimed to have seen 'angels on the wings' [P8, P9]. The youngest passenger whom we interviewed recalled his mother 'flicking through' her rosary beads 'doing her own incantations' as she sat with her 'little blue prayer book' [P13]. Another passenger described how she spent time reconciling with her faith:

I spent a lot of the time being preoccupied with whether I was going to go to heaven or not. The guy next to me, he was sort of down, sort of crouched over. And I said to him 'what are you doing?' and I think he said, I think he said he was praying. [P3]

Additionally, there were examples of passenger praying for one another, as one interviewee recalled:

The lady that was sitting beside me, very nice lady from London, she started crying and she actually grabbed my hand and grabbed my sister's hand, and she was wrapping her rosary beads all around them. And she said, 'I'm going to pray for all of us. Don't worry.' When we came to get off the plane, we had to spend a lot of time undoing those rosary beads because she flatly refused to have them cut. [P11]

In passenger Betty Tootell's book on the event, she writes of another passenger: 'She did not regard herself as a religious person, but now she prayed to God, asking Him to save everyone' [45, p. 86].

4.4.3. Practical actions

Many interviewees recalled instinctively taking practical precautions including writing letters to family, putting on oxygen masks or life jackets, as well as removing shoes and impractical clothing. For instance, one passenger described removing her tights after thinking: 'That's going to burn, and that's going to stick to my legs so if I do have an inkling of being able to survive, I don't want those on. So, I actually took them off' [P4]. For cabin crew, the practical actions conducted involved following procedures such as clearing the cabin, checking bags were stowed away underneath seats and, clearing emergency exits. There were several reports of cabin crew rearranging passengers so that younger, fitter passengers were close to the emergency exits. One member of the cabin crew also described explicitly giving instructions to passengers on how to open the emergency exit should something happen to him:

I said to them, 'I need to teach you something and tell you something.' I said, 'I want you to learn how to open this door if needs be.' And they said, 'well, why is that?' I said, 'well, let me be blunt. If something happens to me, that door needs to be open. I might open it, and something could happen to me, and then somebody has to take over and make sure that door gets open, and people get out'. [P16]

For the flight deck, behaviours were largely centred around decision-making, communication with crew and passengers, and technical procedures such as trying to re-start the engines. The most prominent memory of the event retold in many of the interviews was of the now infamous announcement made by Captain Moody. As well as telling the passengers 'We've got a small problem in that all four engines have failed. We're doing our utmost to get them going. I trust you're not in too much distress.' he also reported that he added 'And would the chief cabin crew member please come to the flight deck.' which 'told the whole crew that we were in trouble' and to prepare for a 'ditching' [P15].

4.4.4. Other coping behaviours

A final sub-theme revealed in the data analysis were passengers' accounts of other coping behaviours. Respondents reported carrying out actions such as filing nails, reading, looking at personal items and taking photographs of the cabin. In one account, a passenger recalled:

I actually had forgotten until now that I took photographs in the cabin. I had a little, I think it was like a little Minolta with a 110-type film, a little kind of camera thing and I took these photographs in the cabin with the masks down. [P2]

Other passengers recalled using humour to cope with the severity of the situation [48]:

The plane was in these sorts of violent convulsions and [wife] said, 'I think the wings are going to fall off'. I said to her, 'okay, take your shoes off. Because if this thing goes down in the ocean and we need to get into a life raft, we need to go out. You don't want your shoes on.' And then my wonderful wife said, 'Well if we end up in the life raft, we won't go hungry because I've got the top tier of our wedding cake in my bag under the seat.' And so there was a little bit of humour, and we were holding hands, of course. [P9]

4.5. Behavioural influences

Our analysis revealed a number of social and environmental factors which appear to have shaped how people onboard the flight behaved or responded. These include a sense of camaraderie, prior knowledge of aviation, upbringing and cultural background, and the behaviour of others.

4.5.1. Responsibility

As mentioned previously, several passengers, as well as one crew member, described acts and behaviours such as closing the blinds to protect others from seeing the alarming scenes that were unfolding. Others recalled downplaying their knowledge of what was happening or shielding their own emotions to prevent frightening elderly relatives or young children. For instance, one passenger who was travelling with her mother described:

I was very conscious that my mother had angina. I remember thinking I've got to reassure her. I don't want her to have a heart attack. So, for me, my focus was right, we're in a bit of a pickle here. I trust planes and, in a way, naivety is a wonderful thing ... My mother knew she was going to die. Would she tell me that? No. She wanted me to die, you know, at least slightly happy or something. [P5]

For the crew, and the pilots in particular, this sense of responsibility manifested as guilt as they tried to understand what had gone wrong. As the First Officer stated:

At the time we didn't have a plan ... the very first feeling we had when that happened was an enormous rush of personal guilt ... a personal guilt. It was all a case of what have I done wrong? What have I missed? [P17]

Cabin crew members also described feeling a responsibility to hide emotions in order to remain professional. As one of the crew members recalled:

I suppose it was the training with British Airways and the fact that there's all those people looking at me. And I had to be strong on an aircraft because that's my job. I couldn't fall apart. [P16].

As seen in some previous quotes, it was also clear that some cabin crew chose reassurance (that everything would be fine) as the responsible action to keep passengers calm, even though they did not know what the outcome of the crisis would be.

4.5.2. Knowledge of aviation

Several passengers onboard flight BA009 held prior knowledge and experience of aviation which influenced their emergency response. For instance, two passengers onboard, who were brothers, had aircraft experience. One had a pilot's licence, while the other had a background in mechanical engineering. In having this knowledge and experience, the brothers responded, 'in a fairly practical and pragmatic way' [P2]. For example, they attempted to diagnose the problem between themselves, by observing phenomena such as the direction and smell of the smoke, from which they deduced the problem could not have been caused by someone smoking:

One would notice that the smoke from the smokers would go upward and out through the ventilation system. But we noticed that the smoke was coming down into the cabin from the ventilation system. And that was very significant for us because we had experience with aircraft. [P2]

With no fire onboard, the brothers concluded that the problem must be an overheating issue and, hoping 'the systems would manage', he recalled, 'I just kind of relaxed' [P2]. Another passenger, who had trained as a pilot in the 1970s, explained that having knowledge of the 'principles of flight' allowed him to understand why the plane might be shaking so violently, therefore controlling feelings of anxiety. Other passengers onboard the aircraft included a member of Air New Zealand staff on standby, and the daughter of a British Airways pilot, both of whom explained their more indifferent response to the event in terms of having done 'quite a bit of flying' [P3] and having grown up with knowledge of aviation. For instance: 'I think having Dad in the airline, I mean he was pretty factual, you know. He didn't sugar coat anything with us about flying' [P4].

4.5.3. Upbringing and cultural background

Another prominent theme in understanding passenger behaviour was a tendency among respondents to associate or explain their behaviour and responses in terms of their upbringing and cultural background. For instance, when asked to recall his response to the incident, Captain Moody replied:

Well, I was going to drag that aeroplane with the other two [flight deck crew] as well. They were dogged north country people from Yorkshire. I'm a ready minded person from the south of England in Hampshire, and my granny always brought me up to believe there's no such word as 'can't' in the English language. 'You *can* do, my boy!'. And I mean I was convinced that once that engine started, we were going to get out of it. [P15]

Similarly, a member of the cabin crew credited his 'exuberant' and 'strong character' as a 'Yorkshireman', rather than his training or 'the company line' [P16] that aided his handling of the situation.

4.5.4. Behaviour of crew

By far the most cited explanation for the absence of hysteria or panic during the incident was the professionalism of the crew and bravery of others. When asked about the actions of the cabin crew and how that made passengers feel, many responses mentioned the bravery and competence of the crew, for instance:

But we could have been on any other airline apart from BA and never come out of this. Because Eric Moody, at the time, would have been the youngest captain, in his forties and the other guys, we were lucky we had that crew that night. You know, well experienced, well trained. That calmness that you know. None of the crew showed any sign of panic, and I think they'd instilled into the passengers a huge amount of confidence about 'okay, everything's going to be alright'. [P6]

One passenger recalled thinking:

I can't do this, I can't swim and panic sets in, but you try and hold yourself together because they're [the crew] setting the example and if they can hold themselves together, then as a passenger, you know, you must try and do the same thing because they're setting the example. You see their bravery and you really don't want to let go and get silly and panic or anything. You just think well if they can be as brave as that then, you know, you've got to keep it all together, and that's virtually what happened for most of the people I think on the plane, including me. [Passenger interviewed for 'Falling from the Sky', *National Geographic* 2006]

5. Discussion

This qualitative study of the narratives of survivors of flight BA009, which flew through the ash cloud of Mount Galunggung in 1982, provides new insights into human behaviours in disasters and emergencies and the risks of volcanic eruptions to civil aviation. The study responds to calls for a mounting need for disaster research and emergency psychology [13], a greater awareness and appreciation of the psychological needs and reactions of air travellers [8] and demonstrates the value of disasters as a unique location in which to observe the human condition [37] and the resiliency found in social networks and social structures [49]. In the following section, we situate results within a larger body of disaster research literature and make suggestions for future research to further examine the implications of volcanic eruptions on the aviation industry and its performance.

Ordinary health complaints experienced during, or as a result of, air travel include jet lag, motion sickness, claustrophobia,

thrombosis and anxiety, among others [8]. The acute health risks associated with airborne volcanic emissions such as volcanic ash, gas (particularly sulfur dioxide) and aerosols include mild respiratory symptoms such as irritation of the airways, cough, and shortness of breath but, also, exacerbation of respiratory diseases, such as asthma. Such exposures can also cause eye and skin irritation [9]. Studies examining residents living in areas exposed to volcanic emissions have found moderate to severe health consequences following exposure to volcanic emissions [9,50,51].

Any of these symptoms of exposure to volcanic emissions could occur at altitude and may be exacerbated (or have a lower exposure threshold for symptoms) due to the pressurised cabin environment [16]. On the other hand, modern planes' environmental control systems (air conditioning) include a HEPA filter which will filter out particles (but only once they are exiting the cabin), prior to re-circulation, thereby reducing particle (but not gas) exposures [16].

The physiological reactions experienced by survivors on flight BA009 included mild respiratory complaints (i.e., coughing or a worsening of asthma); psychosomatic symptoms (i.e., trembling) and minor physical irritations such as sore eyes. While the existing literature would suggest an elevated level of risk to health and physical vulnerability, in the particular case of flight BA009, very few physical health impacts from exposure to what participants described as 'smoke' or 'dust' and no long-term respiratory complications were reported. Nevertheless, a compelling case of a chronic psychosomatic impact was reported, in the case of the Captain's hair suddenly turning white in the months following the incident, which aligns with findings on physical health impacts following a single exposure to trauma [52]. Moreover, another member of the crew perceived to have developed an autoimmune disease following the event, attributing the onset of psoriasis to stress, which he reported was a direct result of the incident. This aligns with research which has described the role of stress/psychological origins of psoriasis and the impact of psychological distress on the individual's experience of the condition [47].

The most pertinent aspect of the narratives of flight BA009 were the rich and insightful accounts of how people onboard felt and responded, which challenge a number of myths concerning survivability and human behaviour during aircraft emergencies (e.g., Manchester B737 incident). At the time of the incident, nobody understood what had happened beyond an understanding that the engines had failed and various other sensory signs, such as smoke, the sight of flames from the engines, and sudden descent, signalled an emergency. Initial thoughts and actions at the time of the incident varied, with most people trying to make sense of what was happening, taking practical precautionary actions, and following guidance from the cabin crew to keep calm, while some were paralyzed by fear, uncertainty, and thoughts about how they might die.

While fear and anxiety were present, 'mass panic' was absent and distress responses were uncommon, with only two clear examples of distress cited, for example accounts of a husband who slapped his wife who was screaming, and the woman who pleaded with the crew to hide her baby, although there were other reports of people crying. Overall, the accounts of responses provided by participants were largely calm, practical, or fatalistic.

This aligns with existing literature on emotional responses to disasters from the field of disaster mental health research, in which studies have identified the presence of both humour, calm, and fatalism in responses to a traumatic event [35,53]. In the present study/case of flight BA009, the sense of calm displayed by those onboard could be explained by the psychological theory of social contagion. Social contagion has been defined as "the unintentional transmission of one's behaviours, attitudes and motives to people in their social environment" [54]. We believe this is also an example of instrumental social support where the crew focused on practical and behavioural strategies to support passengers [55]. Our results therefore stand in some contrast to the panic model of behaviour which assumes that individuals will become overwhelmed in emergencies, leading to confusion, irrational, selfish or competitive behaviour [56,57]. Instead, these findings support critiques of the panic model which argue that, even when gripped with fear or feeling at the mercy of the situation, individuals are capable of making calm, rational, and proactive decisions during an emergency [13,31,58–60].

These results are valuable for two reasons. Firstly, as aviation emergencies are often fatal, this study allowed us to examine rarely available data which demonstrated what happens in the minutes during an aviation disaster, including how both passengers and crew responded and behaved. Second, these results are important as research suggests that, in most aviation emergencies, fatality is often mediated by passenger and crew behaviour, rather than the extent of the accident [8]. Recent evidence of this can be seen in the Japanese (Haneda airport) incident in January 2024, in which multiple reports of the runway collision attributed the lack of fatalities on flight JAL516 to the rigorous training of the crew and calm, 'well-behaved' demeanour of passengers who 'obeyed safety protocols' [61]. Crew 'stoicism', despite sustaining injuries themselves, was reported following the May 2024 turbulence disaster for Singapore Airlines flight SQ321 [62].

Most passengers that we interviewed were travelling with friends or family or, in the case of the crew, were surrounded by colleagues, and so were with someone familiar and behaved in a way that corresponds with social attachment and affiliation models [63]. Our findings also correspond with the self-categorisation model and emergent norm theory [64] which stress the importance of a sense of common identity within informal groups which can inform altruistic behaviours. This was evident, for example, where passengers closed the blinds to protect others from the sight of the engine flames, as well as instances of reassuring strangers, holding hands, and praying for one another.

These behaviours resonate with other qualitative studies of disaster responses such as a study of the immediate reactions of survivors to the Oklahoma City bombing, which describes a similar array of responses and emotions [15]. A review of survivor's emotional, behavioural, and cognitive responses during disasters describes a similar set of responses [13]. In their analysis of survivor responses to disasters, including collapse of a building, earthquake, fire, flood, and terror attacks, Grimm et al. found that, while behavioural cues and the ability to recognise what was happening varied across events, survivors' responses and range of behaviours tended to be universal [13]. It is the view of the Royal Aeronautical Society (RAS) that, in an emergency situation such as an evacuation, behaviour can be either positive (acting calmly or courageously), or negative (acting selfishly or aggressively) [65]. In our

study there were no accounts of aggression or passengers behaving selfishly or displaying negative behaviours.

One of the key contributions of our analysis of narratives of flight BA009 is the identification of social, environmental, and psychological influences which shape behavioural responses to an aviation emergency. In this study, these included a sense of responsibility, prior knowledge of aviation or, for crew, a sense of 'airmanship', character and identity, and the behaviour of others. These findings align with Bor [8] and Galea's [30] observations that the causes or 'triggers' of passenger behaviour are multifactorial, and a wide range of variables can mediate how passengers cope with the stress of an emergency, ranging from their personality, cultural background, gender, and age, to the unique cabin environment. Our findings contribute to this literature by emphasising that behaviour during an aviation crisis, such as encountering a volcanic ash cloud, may take many forms and that diverse influences such as faith, cultural background, responsibility, and prior knowledge of aviation, and expectations of the airline, have important roles in shaping decision-making and behaviours during a crisis.

6. Limitations

When studying survivors' experiences of traumatic events, researchers have highlighted the importance of considering the function and reliability of memory [13]. As these studies have shown, while people who experience these events firsthand are likely to recall disaster details clearly and accurately, even when a number of years have passed, there may be times when memory becomes impaired or narratives are shaped by wider discourses, such as newspaper reporting or film and television depictions of the event [13,66–68]. Some studies have found improved recall among survivors with emotional involvement and direct exposure to disasters [69], suggesting that heightened emotional states may improve recall. Other studies have found a connection between post-traumatic stress disorder (PTSD) and impaired memory function [70]. Consequently, it is important to consider post-traumatic stress symptoms when examining narratives of disaster experiences and the potential for these to impact upon memory and recall [13].

In our study, conducted forty years after the event, we found only minor descriptions of post-traumatic stress with few accounts of long-term mental health consequences (to be published in a separate article), suggesting memory was dependable, in most cases. Most participants could recall the event clearly and had no difficulty answering the questions. This is suggestive of the mechanism known as 'flashbulb memory', a form of associative memory [71] in which individuals maintain a vivid, long-term memory following exposure to a traumatic event, such as a disaster or terror attack [72–74]. This further aligns with research which demonstrates how recall of traumatic events is generally accurate among eyewitnesses [75,76]. Nevertheless, in our study, we discovered variations in one crew member's memories of the event, with different accounts of how they felt at the time of the incident between a diary entry written on the night following the incident and their interview recording. Both memory and intersubjectivity must therefore be taken into consideration when examining narratives of disaster experiences many years after they occurred, as both can shape the account provided.

Nevertheless, conducting this study forty years after the event allowed us to investigate how the event influenced the rest of the lives of the participants (to be presented in a separate article), which is extremely valuable. Furthermore, the BA009 flight became infamous; Betty Tootell's book was published using passenger and crew interviews, and there have been numerous television documentaries, press articles and other media involvement. Additionally, the Galunggung Gliding Club and social network allowed participants to learn from each other's experiences and knowledge of events. Overall, these built a narrative which all of our interviewees will have been influenced by, to some extent.

With regards to the limited number of participants, the study was bounded by how many of the aircraft occupants we were able to contact and were willing to participate. We further acknowledge the presence of survivor bias, as only individuals willing to recount their experience were included. The identification of the passengers was dependent on names given in secondary data sources and by Captain Moody. There is no doubt that the study was therefore biased to passengers who had engaged in previous interviews or the Galunggung Gliding Club, and most of those were English speaking, but this is also representative of the majority of passengers on the plane. It was therefore not possible for this study to give a wide range of cultural perspectives.

7. Conclusion

This study sought to examine the warning signs, health impacts, emotional responses and behaviour of people who experienced the BA009 crisis in 1982. It also examines social and context-related factors that may have influenced people's reactions to the incident.

The thematic analysis shows that the passengers and crew noticed several warning or sensory signs that alerted them to an emergency: smoke, (apparent) St. Elmo's fire, engine flames, other visual signs such as oxygen masks falling from the overhead compartment, both silence and sounds from the re-starting engines, and associated movements of the plane in terms of its descent and bucking/vibrations as various procedures were undertaken by the flight deck crew.

Very few physical health effects were noted from exposure to the volcanic emissions, although there is limited evidence of an exacerbation of asthma symptoms. Additionally, analysis found that the passengers and crew experienced a number of thoughts and emotions: distress, calm, fatalism, and relief, and reacted with four distinct types of behaviour: attending to others; hopeful behaviour (i.e., praying); practical actions (i.e. removing clothes); and other coping behaviours. Lastly, we considered social and environmental influences on behaviour and emotional reactions and found four key influences, including responsibility and altruism, experience of aviation, upbringing and cultural background and the behaviour of the crew.

In light of these findings, which demonstrate the importance of understanding human factors in order to improve safety, security, and disaster preparedness, this paper contributes practical implications which may benefit aviation planning and communication. While it is impossible to predict the behaviour of all onboard an aircraft in such a unique situation, we suggest the following

recommendations.

- 1) All aircraft carry a supply of disposable N95 (or equivalent) respirators in the event of 'dust/smoke' entering the cabin (use of which will lessen inhalation of particles, but not gas). Such masks could be distributed to those most at risk (asthmatics etc.), or displaying symptoms, but should not be used if oxygen masks have dropped.
- 2) In the event of an aircraft encountering a volcanic plume, it should be communicated to passengers that the ash/gas is unlikely to cause a severe physical health response, but that asthmatics should have their medication at hand and take it as required. This should reduce anxiety about inhaling the emissions.
- 3) In any aircraft incident, a calm and professional response from the crew will likely instil confidence and reassurance in passengers, which can minimise the likelihood of negative behaviours.

Forty years after flight BA009 lost all four engines flying through the ash cloud of Mount Galunggung, this paper marks an important milestone in disaster history and emergency response. This research has contributed new insights into the health hazards associated with aviation encounters with volcanic eruptions, as well as passenger behaviour in emergency situations, and points the way forward for future research.

CRedit authorship contribution statement

R. Meach: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **C.J. Horwell:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization. **I. de Terte:** Writing – review & editing, Supervision, Methodology, Data curation, Conceptualization.

Self-reflection of interviewers

The interviews for this research were conducted by Professor Claire Horwell, a volcanologist (who works across the natural, social and health sciences) who researches the health hazards and impacts of eruptions, and Dr Ian de Terte, a clinical trauma psychologist.

Claire Horwell reflexive statement

As the principal investigator of this project, I spent time, prior to designing the interview questions, learning about the BA009 incident. This included reading news articles online, watching documentaries and reading Betty Tootell's book. This was essential in order to be sufficiently informed to design pertinent questions, but also meant that I had prior knowledge which may have influenced how I asked questions. I had also been part of a UK Department for Transport review of the behavioural and health impacts to occupants of aircraft encountering volcanic emissions (Horwell et al. [16]) and I mentioned this in the interview with Captain Moody when he was discussing the organizational and UK Governmental response to the event. We decided not to include this discussion in the paper, primarily because we decided to focus only on the event, itself. Captain Moody may have made assumptions about my age, assuming that I would not know that British Airways was known as BOAC prior to 1974. Another example of intersubjectivity is that one participant was recruited via a colleague of mine (they work at the same institution), and it came up during the interview that we had that link.

Ian de Terte reflexive statement

I was very fortunate to be asked to be part of this research team by CH. I did not know about the incident and purposely did not read any of the material about the event in order to be unbiased during the interviews. I was extremely fascinated by the interviews and several of the participants stated things that intrigued me. However, in order to maintain common questions to all participants I refrained from going down "rabbit holes." I also used some contacts in New Zealand, namely the Stuff journalist, to ensure that we recruited a good sample which resulted in us recruiting 18 participants, which was far more than we anticipated. Some of the participants became visibly upset during the interviews and it was difficult via Zoom to detect this strong emotion before they became upset. I am very thankful to all participants, and although we advised them that these interviews could bring up memories for them and we discussed support for them, I do not think they were aware of the psychological impact this process could have had on them. I was also aware these discussions or interviews had an impact on me.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2025.105558>.

Data availability

The data that has been used is confidential.

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