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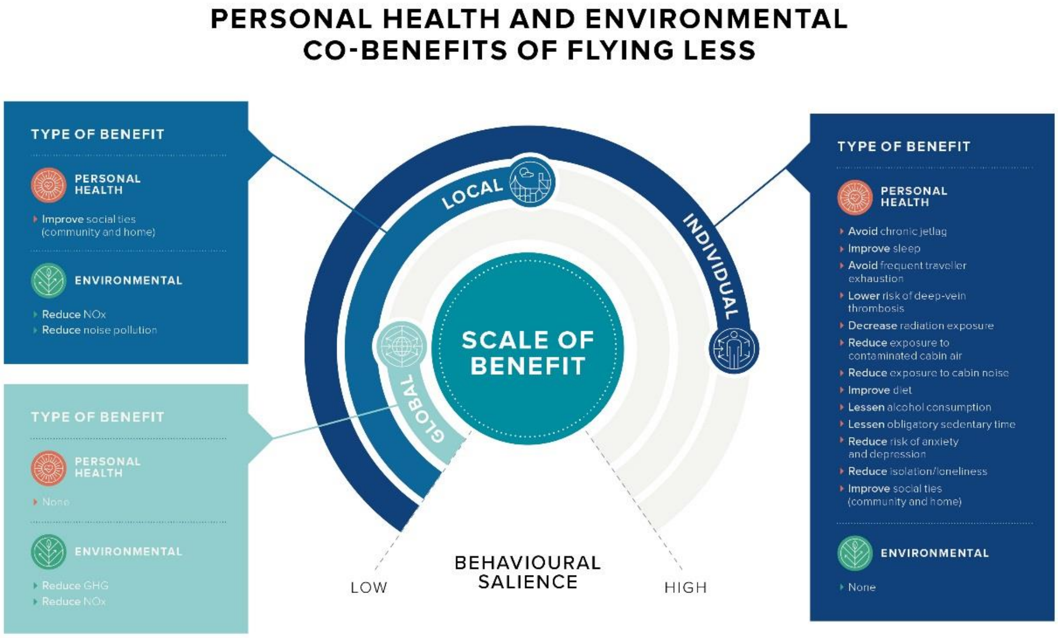
Graphical abstract



Flying less: Personal health and environmental co-benefits

Abstract

Recent and projected growth in global aeromobility is poised to substantially expand aviation's contribution to anthropogenic climate change. With limited prospects for technical- or policy-based reductions in sectoral carbon emissions, behavioural shifts in the form of decreased demand for flying become increasingly important. This conceptual article introduces an innovative approach to aviation demand reduction in the form of a co-benefits approach, wherein conventional pro-environmental messaging is augmented by the articulation of the negative personal health impacts of flying. Using a critical review approach based on secondary literature, we examine frequent flying and theories of environmental behaviour change before examining how co-benefits approaches have been used in other domains. We then identify global and local environmental harms from aviation and synthesise these with the existing literature on the personal health impacts of frequent flying, which includes both physiological effects and psycho-social harms. We find that flying less would engender a much wider range of benefits for individual health, than for the environment, and that the health benefits would likely be more salient for frequent flyers than environmental benefits. We conclude that the personal nature of health impacts will add needed salience and urgency to efforts to reduce unsustainable aeromobility.

Keywords: co-benefits, frequent flyers, environment, personal health, behavioural salience, self-interest

Introduction

Aviation is anticipated to grow at 3.5% per year, and thus nearly quadruple between 2005 and 2050 (IEA 2009). Though presently accountable for 2% of global CO_2 emissions (IATA 2018), aviation's contribution is forecast to rise to 22% by 2050 (Cames, Graichen, Siemons & Cook 2015). Yet just 3% of the world's population flew in 2017 (Sullivan 2018). It is a similarly minor share of highly aeromobile individuals who account for a major proportion of the overall distance flown, with these hypermobile lifestyles closely but not exclusively linked to business travel (Cohen & Gössling 2015; Frändberg & Vilhelmson 2003).

Considerable evidence now exists that frequent flyers, despite often having high levels of environmental awareness, are unwilling to fly less for environmental reasons (Gössling & Cohen 2014). Even the most environmentally aware, who paradoxically tend to fly more than those without pro-environmental attitudes, are unwilling to fly less (Barr, Shaw, Coles & Prillwitz 2010). With this attitude-behaviour gap well-evidenced (Kroesen 2013), and with environmental sustainability arguments for demand reductions in air travel failing to gain traction at consumer, industry or governance levels (Gössling, Cohen & Hares 2016), innovative approaches are needed to move beyond the status quo position that aviation demand reductions can be realised through appealing to environmental sensibilities alone. Arguments for reducing air travel have specifically been too narrowly framed around climate change (c.f. Weaver 2011).

We thus advance in this article – through conceptual argument – a new approach to the discourse of sustainable aeromobility. We take the position that a wider co-benefits approach must be brought to bear on the discourse of aviation emissions reduction, and employ a co-benefits approach to assess, on the basis of secondary literature, the environmental benefits of individuals flying less frequently, concurrently with its *health* impacts (c.f. Cohen & Gössling 2015). Our environmental scope extends to reduced GHG emissions, nitrogen oxides and noise pollution around airports. Taking health as a state of complete physical, mental and social wellbeing (WHO 2006), we evaluate the health consequences of frequent flying, and discuss the potential individual health benefits of flying less. We hope this initial exploratory article will open new avenues of empirical research into how aviation can be moved on to a more sustainable emissions path. It is our contention that a co-benefits approach will provide the evidence needed to construct a more compelling argument for flying less than has been achieved by environmental arguments alone, which can in turn be communicated to publics, industry and policymakers.

Our methodological approach to the secondary literature is a 'critical review' (Grant & Booth 2009). We relied on our own expertise in identifying articles on the basis of their apparent relevancy to the aim of the article (Dixon-Woods et al., 2006b), and appraised these without formal rules of quality assessment (Grant & Booth, 2009).The article therefore follows others who used 'organic, creative and interpretive approaches to conducting reviews of complex literature' in contrast with the rationalist 'frame offered by conventional systematic review methodology' (Dixon-Woods et al., 2006a, p. 38). As we have not adopted the systematicity of a more structured approach, our discussion, which spans a range of literatures across tourism, transport, mobility, health and behaviour change, is not comprehensive and cannot be viewed as an end in itself, but should rather be viewed as a 'launch pad' (Grant & Booth, 2009).

The findings of our critical review are presented and discussed in the following sections, where we first turn to the scale and nature of the phenomenon of frequent flying, before examining theories of environmental behaviour change, co-benefits approaches and their previous applications in other domains. We then focus on the co-benefits of flying less, and examine the environmental and personal health benefits of doing so in turn.

Frequent flying

There is increasing concern that a ‘very small share of share of humanity is responsible for a comparably large share of global emissions’ (Gössling, Cohen, Higham, Peeters & Eijgelaar 2018, n.p.), and it is now evident that mobility plays an important role within this carbon injustice. Earlier studies have emphasised that mobility is unevenly distributed both between and within societies, as ‘a minor share of highly mobile travellers seems to account for a major share of the distances travelled within any given country (Gössling & Nilsson 2010, p. 241). For instance in France, just 5% of the population accounts for 50% of overall distances covered (Gössling, Ceron, Dubois & Hall 2009), while in Sweden only 3% of the population is responsible for 25% of all international journeys (Frändberg & Vilhelmson 2003). This mobility skew has been mainly attributed to frequent flying, as aeromobility allows greater distances to be covered (Gössling & Nilsson 2010). High aeromobility is not only characterised by distances travelled, but also frequency: Gössling et al.’s (2009) survey of Swedish air travellers found individuals reporting up to 300 flights per annum.

Frequent flyers are one of the most profitable markets for airlines, and frequent flyer programmes (FFPs) have been developed as a consequence, with more than 130 FFPs now existing globally (Castillo-Manzano & Lopez-Valpuesta 2014). Whereas growth in FFPs is reaching stagnation in the US, other markets for FFPs worldwide are growing at an impressive rate (de Boer 2018). Though the breakdown by tier (e.g. bronze, silver, gold, platinum) of FFP members is kept highly confidential by airlines, some evidence indicates that the most frequent flyers, or the top tier members, are crucial to airline revenues. For instance, Reales & O’Connell (2017) point out that even though Delta Airlines has 92 million members in its FFP (making it the 2nd largest FFP globally based on revenues), the top 4% of Delta’s customers by spend account for 25% of its revenue. For competitive reasons, many airlines do not make public the level of activity within a FFP, as only a fraction may be active members (de Boer 2018). But it is clear from Delta’s figures alone that a small fraction of frequent flyers are responsible for a disproportionate amount of FFP miles awarded. However, as the reward mechanism of frequent flyer points is shifting from distances flown to expenditure, in order to better reward the purchase of premium fares (Reales & O’Connell 2017), levels of activity within FFPs, where available, still disguise the extent to which individuals are flying frequently, and the actual distances flown.

Whereas FFPs have now been studied in some depth, Castillo-Manzano and Lopez-Valpuesta (2014) state that little attention has been given to the passenger profile behind FFPs. They suggest that while the typical passengers for these programmes have been business travellers, the rise of low-cost airlines has contributed to a changing profile within FFPs, driven by more frequent leisure trips, including for purposes of visiting friends and relatives and second homes. Low-cost airlines, with their emphasis on prices rather than FFPs, have also led to many frequent flyers not being active FFP members. A consequence of these changes is that frequent flyers are no longer as easily delineated as a group. Nonetheless, using a large database of more than 37,000 passengers in the Spanish airport system, Castillo-Manzano and Lopez-Valpuesta (2014) conclude that frequent passengers are mainly older males, who are in employment and with a high level of education and income, and who still predominantly fly for business reasons.

Programmes to change environmentally relevant behaviours like flying rely on a range of theories and behavioural phenomena. Interventions apply insights from behavioural sciences to find leverage points that can pivot people's actions to a more sustainable direction. Efforts to reduce flying based on the environmental benefits alone would likely draw, explicitly or otherwise, on the best developed socio-psychological models of pro-environmental behaviour change.

Theories of environmental behaviour change

The Theory of Planned Behaviour (TPB), a widely used model of behaviour, is an expected-value theory (Ajzen 1991). TPB states that intention is the immediate precursor of action, and that intentions are formed based on a weighting of three beliefs: about the behaviour, about social norms relating to the behaviour, and about one's own ability to perform an action. Behavioural belief is a rational cost-benefit analysis of alternative options, in essence identical to the rational choice model. Under TPB, the expectations of referent others have an influence on intention formation, and, in this way, the theory departs from the rational actor model. Whilst not a theory of environmental behaviour per se, it has frequently been applied to environmental issues, most commonly in ground transportation models (Bamberg et al. 2003; Heath & Gifford 2002). TPB suggests that providing information and changing prices are key methods for changing behaviour.

One of the deficits of the rational choice models like TPB is that they overlook, or are at least not explicit about, the role of morality and altruism in guiding behaviour. Morals and values are particularly relevant in the domain of environmental behaviour, as selecting the pro-environmental choice is frequently at odds with a personal cost-benefit analysis. The Norm Activation Model (NAM; Schwartz 1977) states that personal norms – elements of one's internal value system – are the basis of pro-social behaviour. Personal norms are developed from both understanding the consequences of one's actions and accepting personal responsibility for those consequences. According to the NAM, bolstering the strength of these two antecedents of personal norms can foster pro-environmental behaviour. From this perspective, better informing people about the climate consequences of flying will lead to them to flying less. Though NAM has recorded some success in explaining various energy-related behaviours and intentions (Abrahamse et al. 2009; Black et al. 1985), it poorly accounts for social and institutional external factors, which frequently affect environmental behaviour (de Groot and Steg 2010) and are particularly central to frequent business travel.

The role of personal norms in influencing behaviour was specifically connected to the environment with the development of Value Belief Norm theory (VBN; Stern 2000). This theory, much like NAM, sees awareness of environmental consequences as an antecedent of pro-environmental behaviour. Such awareness is connected with holding biospheric and altruistic values and is negatively correlated with egoism. The VBN theory holds that being aware of environmental consequences generates feelings of responsibility for those consequences, which in turn fosters the personal norm of pro-environmental behaviour in one's public and private lives. Both the VBN theory and NAM have respectable explanatory power for low-cost pro-environmental behaviours, but values-based models falter with predicting high-cost actions (Bamberg and Schmidt 2003), which conceivably include the perceived social, professional and personal effects of reduced mobility.

Classic cornerstones of pro-environmental behaviour change, concepts like understanding and accepting consequences for actions that harm the environment, do not seem to motivate reductions in flying (Gössling & Cohen 2014; Barr et al. 2010). This deficiency in environmentally based interventions suggests that approaches that rely on motivation via non-environmental factors may be an important alternative framework to explore.

Co-benefits approaches

The term "co-benefits" is used when benefits across multiple policy areas are considered in parallel (Giles-Corti et al. 2010). A co-benefits approach will emphasise that many actions to reduce emissions also have wider impacts on health, the economy and the environment (Smith et al. 2016). The perception of personal risk can be a strong motivator for behaviour change (Few 2007). Given that many of the harms associated with climate change are viewed as distant in time and space (Spence, Poortinga & Pidgeon 2012), linking GHG mitigation with more direct and individual costs and benefits has the potential to increase the uptake of climate-positive actions (Petrovic, Madrigano & Zaval 2014).

Other sectors have explored interventions based on co-benefit approaches. Co-benefits approaches have been taken in the domain of reducing meat consumption: Westhoek et al. (2014) examined the consequences for the physical environment *and* human health if EU consumers ate 25-50% less animal-based foods and replaced these with plant foods, and found this would result in a 25-40% reduction in GHG emissions, significant improvements in both air and water quality and that the associated 40% reduction in saturated fat would lead to a reduction in cardiovascular mortality. Co-benefits approaches are also found within household energy interventions, where co-benefits are emphasised in pursuit of both climate and health goals (Wilkinson et al. 2009), and within power generation and energy use in buildings, industry and agriculture, where health and environmental co-benefits have been monetised (Smith et al. 2016).

Whereas a significant body of research documents the co-benefits of different pro-environmental actions, few studies have investigated if and how a co-benefits approach affects individual behavioural intentions, that is, by testing how well such messages motivate behaviour change. An exception is MacKerron, Egerton, Gaskell, Parpia and Mourato's (2009) study of consumers' willingness to pay for voluntary carbon offsets of air travel. The authors find that emphasising the sustainable development co-benefits of offsets (human development, biodiversity and low-carbon technology/market development) leads to consumers being more willing to pay for them. Even though MacKerron et al. (2009) did not test how co-benefits related to individuals' own health affects their behaviour, the findings suggest that a co-benefits approach may provide a stronger stimulus for pro-environmental behaviour than a single-sided environmental argument alone, such as one framed only around carbon reductions.

It is notable that most studies take a *society-level approach* to assessing co-benefits, aggregating costs and benefits across a large number of people and institutions; for example, fewer coal-fired power plants are good for the climate system and for public health in aggregate. The main exception to society-level approaches has been in the transport sector, where co-benefits have been assessed at global, local and individual scales (Barrett et al. 2016), with the latter being of primary interest to the present article. The majority of this work has been conducted within the discourse of ‘active transport’, that is, the use of non-motorised travel modes, principally walking and cycling, for non-leisure purposes.

Co-benefits of active transport

Emphasis on active transport has followed from increasing research interest in the relationships between travel behaviour and health (van Wee & Ettema 2016). Interest in active transport is closely tied to the links between cycling and walking and improved health outcomes, which include higher personal fitness, positive mental health effects, improvements in cardiovascular risk factors and reduction in prevalence of depression, dementia and diabetes (Cavoli, Christie, Mindell & Titheridge 2015). Cycling and walking have environmental co-benefits of reduced GHG emissions, congestion, pollution and noise (Barrett et al. 2016; Grabow et al. 2012). Substantial improvements to both health and climate indicators could potentially be realised through relatively modest substitutions of active transport for motorised transport. For example, Maizlish et al. (2013) suggest that an 18-minute increase in median active transport time by San Franciscans could generate a savings of 40,000 disability-adjusted life-years from reduced illness and traffic injuries whilst reducing GHG emissions by 14%. These health and environmental co-benefits have underpinned calls for prioritising the needs of pedestrians and cyclists over motorists in policy decisions on the built environment (Younger, Morrow-Almeida, Vindigni & Dannenberg 2008; Woodcock et al. 2009).

Yet a limitation in co-benefits arguments in transport is that they have to date focused only on surface transport (Smith et al. 2016). This focus has been driven by urbanisation and the need for safe urban environments for mass active and public surface transport. The result is that studies of travel behaviour and health have excluded air travel entirely (c.f. van Wee & Ettema 2016). Though it has been suggested in transport studies that flying less is one strategy among many for producing co-benefits for the environment and human health (e.g. Younger et al. 2008), further elaboration is lacking.

Co-benefits of flying less

While other sectors have explored interventions based on co-benefits, the argument for reducing air travel has been too narrowly framed around the effects on climate change from aviation GHG emissions (c.f. Weaver 2011). The wider environmental benefits of individuals flying less must be considered concurrently with the health benefits of doing so.

Environmental benefits of flying less

The environmental impacts of the aviation sector are dominated by operations, with the three significant environmental impacts being effects in terms of climate change, emissions of nitrogen oxides (NO_x) and noise. Less flying would therefore lead to reductions in: (1) GHG emissions, (2) NO_x emissions and (3) noise pollution around airports.

GHG emissions

There is considerable evidence that aviation's carbon emissions have consistently grown and will continue growing (Peeters, Higham, Kutzner, Cohen & Gössling, 2016). Aviation's mitigation efforts continue to trail behind that of other sectors (Cames et al. 2015). National GHG inventories and reduction targets cover emissions from domestic aviation (Bows & Anderson 2007). Whilst international aviation is not covered under the emissions reduction path set out by the Paris Conference of the Parties (COP21) on climate change in 2015 (Becken and Mackey 2017) – the majority of its emissions are in international air space and thus not attributable to particular nations – the UN International Civil Aviation Organization (ICAO) has recently approved targets for emissions reductions from this source.

The international aviation sector have thus through the ICAO implemented a fuel efficiency standard and an airline offsetting system in a move towards carbon-neutral growth (Peeters, Higham, Cohen, Eijgelaar & Gössling 2018); however Peeters (2017) concludes that these measures will be insufficient in achieving this aim. In contrast, aviation emissions are still set to play a major role in derailing the target set in the Paris Agreement to keep global temperature rise well below 2°C and pursue efforts to limit it to 1.5°C. Although airlines have become considerably more fuel efficient since the 1960s, prospects for future efficiency gains are small, and emissions growth has outpaced efficiency gains for decades due to the nonstop expansion of passenger volumes (Peeters et al. 2016). So called 'silver bullet' technological solutions, such as biofuels or solar or electric flight, have been exposed as 'myths' and 'hoaxes', which are stalling progress in aviation climate policy (Caset, Boussauw & Storme 2018; Peeters et al. 2016).

NO_x emissions

NO_x is an umbrella term for nitrogen oxides that are considered air pollutants, particularly nitric oxide (NO) and nitrogen dioxide (NO_2). Aviation-based NO_x is formed through high-temperature combustion that occurs during airplane engine operation, with aircraft accounting for about 1% of total global emissions (Miyazaki et al. 2017). NO_x gases contribute to acid precipitation and, by reacting with volatile organic compounds and sunlight, are key to the formation of smog/ground-level ozone and secondary particulate matter, known causes of respiratory disease (Kampa & Castanas 2008; Anenberg et al. 2017).

Whilst NO_x itself is not a GHG, its presence in the troposphere catalyses the formation of ozone, which is the third greatest contributor to radiative forcing (Solomon, Qin, Manning, Averyt & Marquis 2007). Through a different set of reactions, atmospheric NO_x emissions serve to reduce methane levels (Isaksen et al. 2014). Globally, the increased radiative forcing from NO_x-induced ozone formation is greater than the climate benefits of methane reduction (Lee et al. 2009). Generally, landing- and take-off-associated NO_x emissions are regulated while cruise emissions are not, meaning that cruise emissions can be expected grow at approximately the same rate as air traffic (ICAO 2008).

The contribution of airports to community exposure to other forms of air pollution is a creditable health concern. Both aircraft and ground vehicles travelling to and from the airport can increase ambient levels of NO_x, carbon monoxide and respirable suspended particles (Yu et al. 2004). A recent assessment of local environmental impacts of American airports found that air quality damage by airports could be as high as USD400 per person per year for local populations (Wolfe et al. 2014).

Noise pollution

Noise is unwanted sound and is a form of air pollution (Goines and Hagler 2007). The preponderance of studies of aviation-based noise pollution have focused on community-scale harms to health and wellbeing. Noise from a major airport can have measurable negative impacts on communities up to 20km distant (Wolfe et al. 2014). Though the primary source of aviation noise pollution is the overhead transit of aircraft, we could expect that there would be a second-order effect of noise generated by traffic associated with a local airport.

Chronically elevated noise levels have been associated with numerous physiological ailments. Franssen et al. (2004) describe a correspondence of exposure to aviation noise with poor general health. Aircraft noise has been specifically linked with hypertension (Jarup et al. 2008; Kaltenbach et al. 2016), cardiovascular disease/myocardial infarction (Correia et al. 2013; Kaltenbach al. 2016; Basner et al. 2013), and disrupted sleep (Bronzaft et al. 1998; Morrell et al. 1997).

Aviation noise pollution can also have an impact on non-physiological well-being. Kaltenbach et al. (2016) review evidence that aviation noise is linked with reduced reading abilities and other educational attainments by children. Noise pollution in general has a negative impact on subjective wellbeing (Dolan et al. 2008). A study of people living close to Amsterdam's Schiphol Airport indicated that whilst objective noise levels (as measured in decibels, dB) did not correlate with wellbeing, one's subjective experience of noise did have a significant and negative affect on wellbeing (Van Praag and Baarsma 2005). The subjectivity of noise impacts has been observed elsewhere, with a meta-analysis by Kaltenbach et al. (2016) indicating that aviation noise is more disturbing than ground transport noise of the same dB intensity, while other research finds that the number of people "highly annoyed" by aircraft noise is more than a factor of four greater than those who are annoyed by ground transportation noise of the same volume (EEA 2010).

Despite air travel's considerable environmental impacts in terms of GHG emissions, NO_x emissions and noise pollution, arguments for demand reductions in air travel based on environmental reasons alone have not yet gained traction at consumer, industry or governance levels (Cohen, Higham, Gössling, Peeters & Eijgelaar 2016; Gössling et al. 2016). It is important to note that the environmental benefits that would accrue from reducing these impacts would primarily take place at local (noise and NO_x emissions) and global (GHG and NO_x emissions) scales. Thus little direct benefit to the self-interest of frequent flyers themselves is provided, whose relative affluence suggests they are unlikely to live directly under flight paths within close proximity to airports (c.f. Haines, Stansfeld, Head & Rob 2002; Rahmatian & Cockerill 2004), and have been shown in numerous studies to view air travel's climate impacts as a problem, albeit one too distant to engender actual behavioural change (Higham, Cohen, Cavaliere, Reis & Finkler 2016).

Health benefits of flying less

While the environmental benefits of flying less are reasonably well established in academic literature, especially in terms of climate change, the health impacts of flying less have received little academic attention. This is surprising given that the health benefits of flying less will be of salience to the self-interest of frequent flyers. Considerations of self-interest have been shown to dominate public preferences towards aviation policy options (Kantenbacher, Hanna, Cohen, Miller & Scarles 2018). We argue that by bringing an understanding of the health impacts of flying less side-by-side with the environmental benefits, an innovative and powerful co-benefits argument is produced that can be communicated to publics, industry and policymakers.

The evidence base on many of the personal health impacts of frequent flying is weak – quantification is lacking and assessing levels of risk based on flying frequently is not presently possible. There is furthermore little evidence as to whether frequent flyers are aware of the health impacts of frequent flying. It is clear from Cohen, Hanna & Gössling's (2017) study of public comments to media reporting on these health impacts that some self-identified frequent flyers have developed strategies to mitigate the personal impacts, whereas others lacked information about the potential harms altogether.

Before turning to the benefits of flying less, it is important to acknowledge that flying does provide some personal benefits, such as the potential to learn more about the world and other cultures through physical co-presence, experiences of different geographies and climates and the ability to maintain social ties and provide care to overseas friends and relatives (Janta, Cohen & Williams 2015). Flying for business purposes is alleged to provide enhanced professional status, great understanding of cultural differences and increased open-mindedness (Beaverstock, Derudder, Faulconbridge & Witlox 2009; Gustafson 2014).

Following the World Health Organization (2006) to frame our understanding of health and flying, we understand health as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity". The health consequences of frequent flying are largely shouldered by frequent business travellers, though flying frequently for leisure purposes can also harm personal health (Cohen & Gössling 2015). Whereas cycling and walking associated with active transport can accrue positive health benefits to individuals such as higher personal fitness, at a physiological level, flying less will reduce a number of harms.

Circadian rhythm misalignment through frequent flying is one of the most powerful ways in which frequent travel can impact health. Jet lag associated with flying across time zones can make people feel unwell as the body cannot adapt its internal cycle of sleepiness and alertness quickly enough to align with the shifted external cues (e.g. the timing of day and night). There is evidence from shift workers, professional athletes and surgeons showing that frequently disrupted sleep patterns and/or the disruption of the circadian rhythm has negative health impacts and affects performance (e.g. Archer et al. 2014; Song, Severini & Allada 2017). It has been shown that just 17 hours of sustained wakefulness causes impairment equivalent to a blood alcohol content of .05%, which is illegal in many industrialised countries (Dawson & Reid 1997).

There is increasing recognition that modern lifestyles are chronically disrupting our natural circadian rhythms, with potentially far-reaching health consequences in the forms of obesity, heart disease, diabetes and cancer. Media coverage of the awarding of the 2017 Nobel Prize for Medicine – given for the discovery of how circadian rhythms are created – drew particular focus to the societal implications of chronic disruption of the circadian rhythm for shift workers and frequent flyers (Devlin 2017). Disruption of circadian rhythm affects mood, judgement and concentration for up to six days after flying across many time zones (Striker, Dimberg & Liese 2000). Jet lag is not just episodic, as chronic jet lag among airline cabin crew has been shown to cause memory impairment, and it affects gene expression that influences aging and the immune system, thereby increasing the risk of heart attack or stroke (Archer et al. 2014; Knapton 2014).

Less flying will not only reduce the risks of increased exposure to germs within airline cabins and getting deep-vein thrombosis, the latter of which develops symptomless in one in ten travellers on long-haul flights (Scurr et al. 2011), but will also mitigate the harms associated with radiation exposure, contaminated cabin air and cabin noise. Radiation exposure during air travel is hundreds of times higher than at ground, with calls to classify frequent business travellers as radiation workers, as flying just 85,000 miles per year exceeds regulatory limits for public exposure to radiation facilities (Barish & Dilbert 2010; Cohen & Gössling 2015). Less recognised is the flight safety implications of contaminated air on flights, dubbed the "asbestos of the skies", and which may acutely or chronically expose frequent flyers to oil fumes or other hazardous chemicals as a result of faulty bleed air filtration, known as "fume events" (Haines 2017). A fume event may cause a range of health problems, termed "aerotoxic syndrome", though the Civil Aviation Authority denies the long-term health effects from contaminated cabin air, despite scientific evidence calling to classify aerotoxic syndrome as a new occupational disease (Michaelis, Burdon & Howard 2017). Chronic exposure to aircraft cabin noise, which has been measured at an average of 80 to 85 dBs, though with higher sound pressure levels when the engine starts and the plane takes off, has been recognised as an occupational hazard among cabin crew and shown to increase the risk of both hearing loss and heart disease (McNeely et al. 2014).

Frequent flying is furthermore associated with less regular exercise, worse eating habits than at home and drinking too much alcohol (Gustafson 2014). The majority of business travel is facilitated at a global level by flying (Beaverstock et al. 2009): indeed Richards and Rundle (2011) find frequent business travel is linked with sedentary behaviour, obesity, high cholesterol and poor self-rated health, while Burkholder, Joines, Cunningham-Hill & Xu (2010) find it to be associated with sleep deprivation and excess alcohol consumption. Particularly in the case of frequent business travel, with its early mornings, late nights and intense working days, the combination of jet lag, stress and fatigue may turn chronic, and has been characterised as "frequent traveller exhaustion" (Black & Jamieson 2007; Ivancevich, Konopaske & DeFrank 2003).

Flying less may also improve wellbeing, mental health and work-life balance by reducing forms of psycho-social harm that have been associated with frequent travel and considerable periods of time away from one's usual place of residence (c.f. Cohen & Gössling 2015). Employees who travelled internationally for World Bank have for instance been shown to have a three-fold increase in psychological claims as opposed to non-travellers (Liese, Mundt, Dell, Nagy & Demure 1997). Studies of the psycho-social impacts of frequent business travel document isolation and loneliness, a reduction in the traveller's social ties at local and community scales, thereby undermining social cohesion and the traveller's social capital (Gustafson 2014), and less time for co-present social life at home, despite advances in information communication technologies (Bergström 2010). High numbers of nights away for work per month have been connected to anxiety and depression (Rundle, Revenson & Friedman 2017), feelings of guilt at leaving family behind, and resentment and anger among spouses left at home, who are most often women, and whose own careers may suffer so as to facilitate their significant other's business aeromobility (Bergström Casinowsky 2013; Espino, Sundstrom, Frick, Jacobs & Peters 2002).

In summary, Figure 1 presents what is to the best of our knowledge the first-ever attempt to bring together the personal health and environmental co-benefits of flying less. It emphasises the behavioural salience of benefits to frequent flyers themselves, and clearly shows that personal health benefits are not only the most salient to flyers, but also that a much wider range of benefits exists in terms of personal health, as compared to the environment. Figure 1 provides a concise and visually compelling evidence base for communication of the co-benefits of flying less to publics, industry and policymakers, as well as a basis for future empirical research, as discussed below.

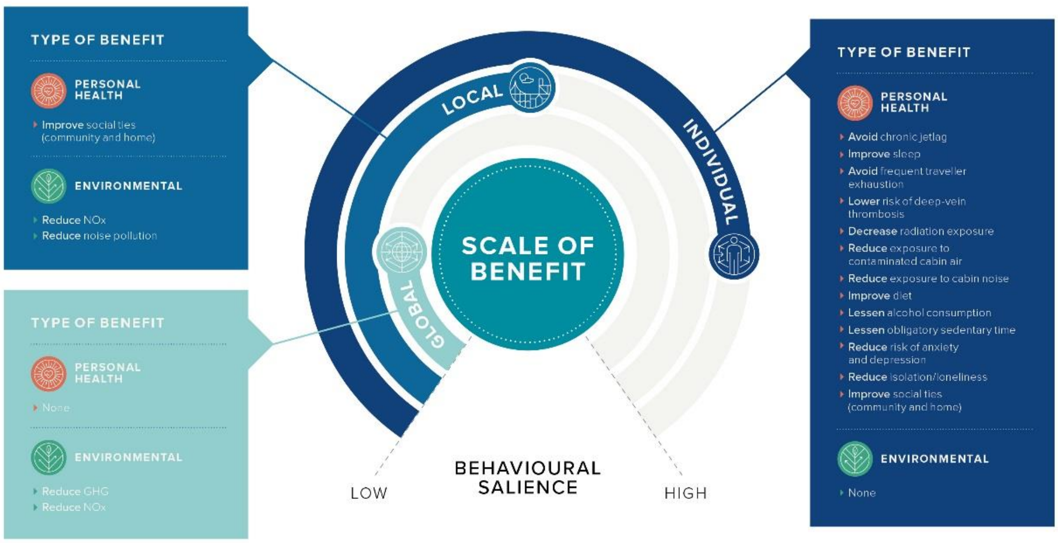


Figure 1. Personal health and environmental co-benefits of flying less

Public health frameworks for environmental behaviour change

There are numerous intersections and overlaps between the fields of environmental sustainability and public health. Climate change and patterns of resource use are understood as threats to public health (Haines et al. 2006; Watts et al. 2015; Bourque &Willox 2014), while the environmental justice movement has its roots in the recognition of disparities in health impacts from exposure to pollutants (Brulle & Pellow 2006). As highlighted above, co-benefits between public health and the environment have been frequently documented (Marolla et al. 2018; Haines et al. 2009), including in the specific case of transportation (Grabow et al. 2011; Shaw et al. 2014).

Despite field-level overlaps and the co-benefits complementarity of public health and environmental sustainability, there are few published instances of health-based impacts being leveraged to motivate pro-environmental behaviour change. When applied, the use of health impacts to argue for environmentally related changes is often channelled toward building community-level resilience and adapting to climate change (cf. Walker et al. 2011; Watts et al. 2015; Keim 2008). Though, to our knowledge, there exist no intervention-type studies examining the efficacy of a health-environment co-benefits argument, there is promising work in the domain of climate change communication which suggests that such an argument has the potential to gain traction. Health-based essays on climate change have been found to be an effective framing for engaging the public (Maibach et al. 2010), while focusing on the public health impacts of climate change has been more effective than environmental or national-security frames in eliciting emotional reactions consistent with support for climate action (Myers et al. 2012).

In advocating for a co-benefits approach to flying interventions, we are encouraged by these framing results. Though the climate communication studies focused more on broad support for climate action rather than specific and personal actions, we can expect that messaging centred on personal health impacts can be likewise effective. Personalising information has been documented to be effective in promoting healthier behaviour (Noar et al. 2007; Kreuter and Ricardo 2003). An important caveat, however, is that self-efficacy is an important mediator of health promotion (Bandura 2004; Strecher et al. 1986), and perceived behavioural control in the domain of flying, particularly for business travel, may be limited for many flyers.

Concluding discussion and further research

The scientific endeavour to find ways to move aviation on to a sustainable emissions path is at an impasse. There is little potential for technological solutions and public behavioural change and policy action based on environmental reasons. The environmental impacts of aviation are distant in time and space to the self-interest of frequent flyers, and it is increasingly clear that self-interest drives aviation policy preferences (Kantenbacher et al. 2018). Innovative approaches such as those based on co-benefits are needed to break this impasse. Frequent flying can impact an individual's health in a range of detrimental ways, and these personal impacts are of great self-interest to frequent flyers (Cohen et al. 2017). The personal nature of health impacts could add great significance to efforts to reduce flying. The people who are most likely to be affected by the environmental damages associated with flying will in most cases not be frequent flyers themselves, as the hypermobile elite are among the best-shielded from the impacts of climate change. In this light, it becomes even more important to articulate to flyers the direct, personal health harms of frequent flying.

Within the context of business travel, business flyers are forced to balance distant and abstract environmental harms against benefits that accrue to their employer, and which thereby have a second-order benefit to the flyer's career. The salience of personal health impacts within this article's co-benefits approach provides a basis for business travellers to juxtapose secondary career benefits with primary health harms. As it has been shown that people place more importance on preventing losses than gaining benefits (Kahneman, Knetsch & Thaler, 1991), the health co-benefits of flying less are likely to be compelling to frequent flyers not only because of their personal relevance, but also because they are about avoiding loss. Whether this has the side effect of muting more altruistic/pro-social values that may influence long-run pro-environmental behaviour is a question that requires further exploration.

To summarise, the present article has revealed that flying less would engender a much wider range of benefits for individual health, than for the environment. Given that the health benefits of flying less are more numerous and likely more *salient* for frequent flyers than environmental benefits, and the limitations of environmental arguments alone in stimulating societal change in aviation demand, it is surprising that no existing study has considered the health co-benefits of flying less. To that end this article has contributed in three main ways: 1) it has introduced a co-benefits approach to the important context of aviation demand reduction; 2) by conjoining the health and environmental benefits of flying less, it has provided a stronger prompt for behaviour change than environmental impacts alone; and 3) it has opened a new pathway for research into how to help move aviation on to a more sustainable emissions trajectory, which demands empirical investigation.

This article has been limited by both its methodological approach and conceptual basis. Our critical review approach means that the article is inflected by our values and our desire to reduce demand for frequent flying. As a conceptual article, we are not able to provide evidence that raising awareness of the personal health impacts of frequent flying, as part of co-benefits messaging to fly less, would lead to significant behaviour change among frequent flyers. For this future empirical research will be needed. But as this paper has shown, a precursor to doing so will be to better characterise the health impacts and risks of flying.

While there have been a range of disparate studies that uncover various health impacts associated with business travel and flying (c.f. Cohen & Gössling 2015), research employing new methodologies would be instrumental in providing more detailed or (for some impacts) objective descriptions of health effects. Laboratory research does not allow for the long-term study of effects within real-world, irregular schedules. Studies of health records can only correlate travel patterns with *outcomes* like obesity and high cholesterol; they cannot examine how factors that cause poor outcomes – like stress, quality of sleep, mental health and wellbeing – are related to travel patterns. Where these factors have been studied, the research has relied on subjective self-report measures, which typically suffer from issues of memory recall due to the time passed between event and survey. To measure the health impacts of frequent flying in-situ, extending Shoval, Schvimer and Tamir's (2017) use of mobile sensors to gather physiological measures of health and wellbeing among frequent business travellers who are 'on the move' will be an important step in providing the fundamental research that can underpin co-benefits messaging to fly less. The precision and accuracy of such research might serve to increase recipient confidence in the content of co-benefits messaging.

Further research will then be needed to empirically test the effectiveness of a co-benefits framing in engendering less flying. Co-benefits approaches have mainly been used at policy levels, with little application to the individual level of public behavioural change. This represents a large gap in the literature on behaviour change, and MacKerron et al.'s (2009) study of co-benefits messaging in the context of voluntary carbon offsets for aviation is an important pivot point for further work. MacKerron et al. (2009) conclude that providers of aviation carbon offsets and policymakers may be able to stimulate greater offset uptake by emphasising its co-benefits. We conclude in a similar manner, by emphasising that future empirical work will not only need to investigate the effectiveness of co-benefits messaging on flying less in terms of individual behaviour change among frequent flyers, but will also need to uncover how co-benefits messaging may engender change in human resource and corporate travel management policies, as well as influence public policy development that will compel individuals to fly less.

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