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Human operators in air transport: A decade of systematic reviews

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Abstract

This meta-review synthesises the literature on air transport research. It focuses on human operators as portrayed in systematic reviews. It aims to identify key trends and suggest future research. Most air transport research has focused on passengers, the environment, and economics. Yet, research on human operators, particularly pilots and air traffic controllers, has lagged. This study fills this gap. It is the first meta-review of human operators in air transport. A comprehensive search, following the PRISMA 2020 guidelines, was done across databases, including Scopus and Google Scholar. The search revealed 588 records, with 41 systematic reviews meeting the inclusion criteria. We synthesised data along three dimensions: context, methods and themes. The review found a growing body of research, especially post-2019. It had significant contributions from Australia, the USA, and the UK. The studies focused on pilots and cabin crew. They addressed mental health, fatigue, and job risks. Methodological rigour was high, with PRISMA guidelines being followed consistently. The findings show a growing interest in human operators in air transport. We propose future reviews to focus on airport ground operators and workforce diversity. Integrating human operators into systems theories could optimise air transport systems. It would make

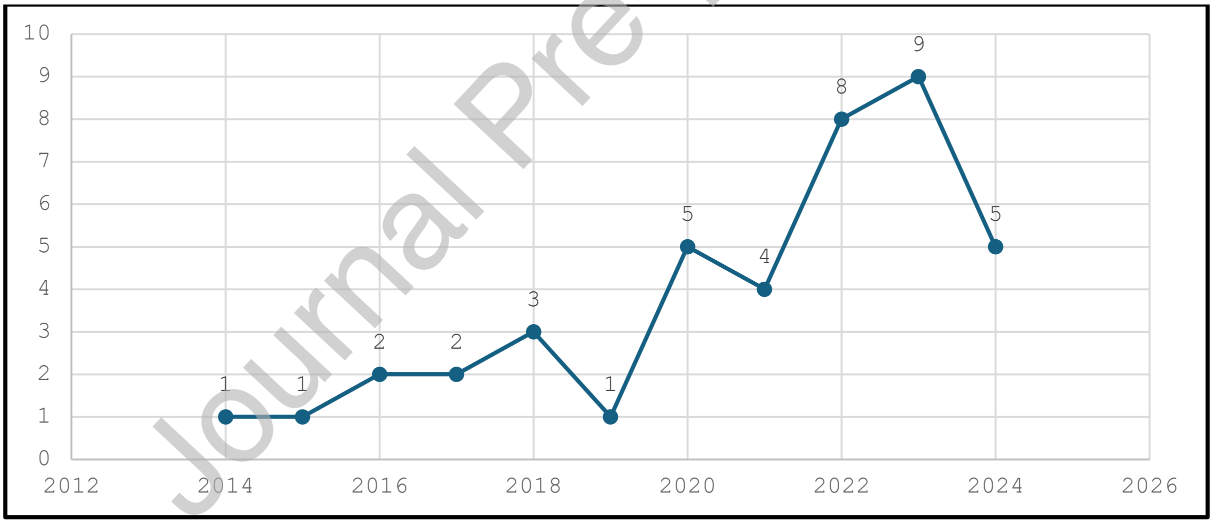
better use of both human and technological resources.

Keywords: Human operators; pilots; cabin crew; Meta-review; systematic literature review

Introduction

Systematic literature reviews are crucial for developing and managing effective, and safe, air transport systems. They synthesise the state of current knowledge in the field (Zhang & Wan, 2024), illustrate the trends (Soklaridis et al., 2024), identify the gaps (Pauwels et al., 2024) and propose future research (Geske et al., 2024). Compared to the established stream of systematic reviews from the standpoint of the occupants (e.g. Philbrick et al., 2007; Santos, et al., 2024) and its role on the environment (e.g. Takeda et al., 2008; Perron et al., 2012) and economy (e.g. Taylor et al., 2010; Graham et al., 2011), work concerning the human operators has, until recently, been lagging. Yet, there is a need "to redefine roles / responsibly accounting for human factors in training and operation" (Wandelt, et al., 2024, p.7).

Figure 1 – Evolution of systematic reviews on human operators in air transport (*n*=41)



Source: *Own elaboration*; **Note:** *The characteristics of each publication are described in Table 1*

Our review shows that 41 systematic reviews on the topic exist. They were published from 2014 in two distinct phases (see Figure 1). The first, from 2014 to 2019, was a seminal period. Interest grew cautiously as 10 systematic reviews formed a substantial contribution. The second phase, from 2020 to 2024, saw rapid growth. The number of systematic reviews more than tripled to 31. This sharp increase over such a short period illustrates that human operators in air transport is a rapidly growing review topic. For this amount of knowledge to be put to maximal use, meta-reviews – the synthesis of the existing literature on a topic as portrayed in extant systematic reviews - are crucial and even necessary (Hennessy et al., 2019).

This paper offers the first meta-review of human operators in air transport research. This is due to air transport's need to assess the knowledge gained on the topic in such a short time. The aim of the meta-review is twofold. First, to find the contextual, methodological and thematic trends in current systematic reviews on this topic. Second, to propose future directions to fill the gaps. In line with this aim, the following research questions will guide this meta review:

RQ1: What are the central identity characteristics of this stream of research (*Contextual*)?

RQ2: How was the relevant research conducted (*Methodological*)?

RQ3: What are the areas of interest (*Thematic*)?

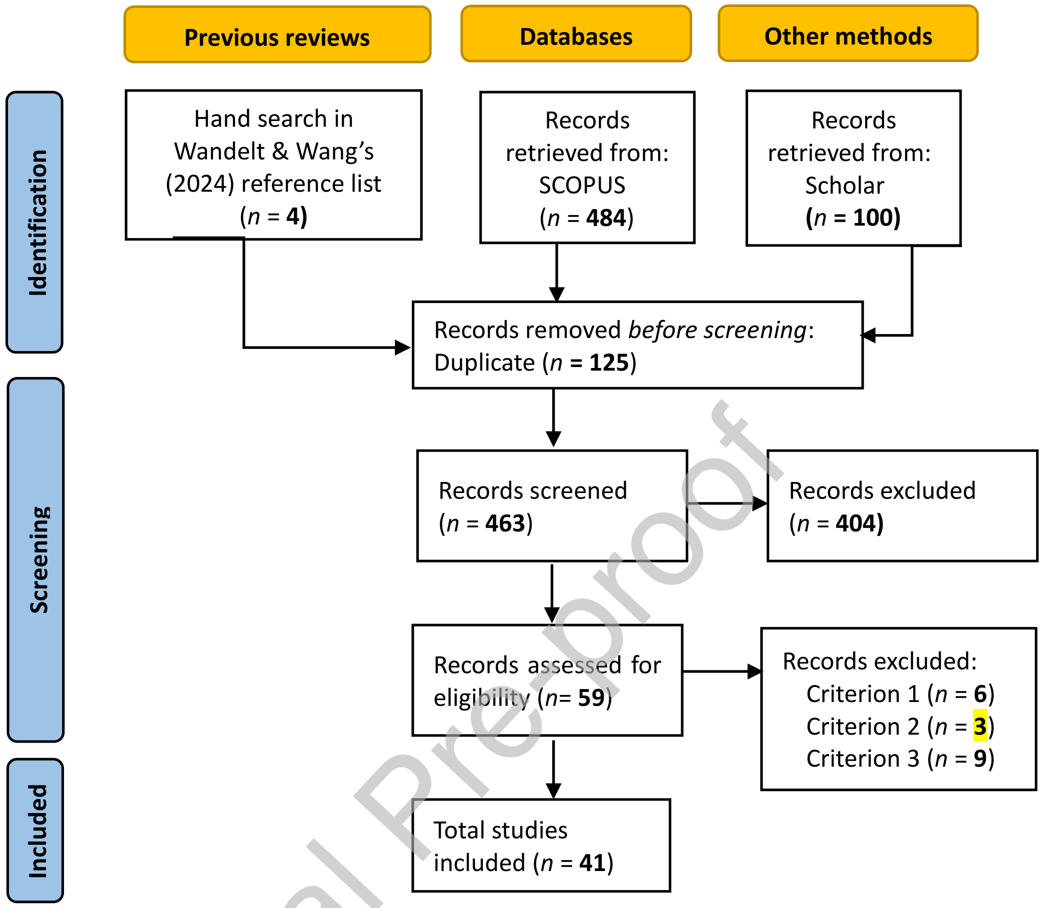
The rest of the paper is organised as follows: Section 2 describes the methodology for the meta-review. It follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The focus is on the search strategy. It details the process used to select the 41 systematic reviews for inclusion. It also covers how the researchers extracted the data to best answer the four questions. Section 3 synthesises the data from the review questions. Section 4 summarises the key contextual, methodological and thematic trends. Section 5 discusses the gaps and suggests ways to improve future research in this area. Finally, Section 6 specifies the conceptual, methodological and empirical contributions of the meta-review.

2. Method

2.1 Search strategy

To be considered eligible for inclusion, the review must focus on an air transport topic related to human operators and explicitly state that a systematic review was conducted. Systematic reviews focusing exclusively on military were excluded. Using this eligibility principle, a three-stage search strategy was conducted (e.g., Papavasileiou & Tzouvanas, 2021; Papavasileiou et al., 2024) (see Figure 2).

Figure 2 – PRISMA 2020 flow diagram and search strategy for capturing the systematic reviews of air transport from the standpoint of the human operators.



Inclusion/exclusion criteria: A review focusing on an air transport related topic (*Criterion 1 - CR_1*), excluding military operators (*Criterion 2 - CR_2*), which includes a statement of a systematic review method (*Criterion 3 – CR_3*),

Database	Search string	Limits	
Scopus	(TITLE ("systematic literature review" OR "systematic review") AND ALL ("airline" OR "aviation" OR "air traffic")) AND (LIMIT-TO (LANGUAGE ,"English")) AND (LIMIT-TO (SRCTYPE , "j"))	Source	Peer-reviewed articles
		Language	English
		Period	No limit
Google Scholar	{"systematic literature review" "air traffic" OR "aviation" OR "airline"}	Source	Peer-reviewed articles, book chapters, thesis, conference articles & technical reports
		Language	English
		Period	No limit

Note: Last search 22 August 2024

First, a manual search was performed in the reference list of Wandelt & Wang's (2024) review of airport ground operators' research. This process revealed four records for further screening. The search was then focused on peer-reviewed publications indexed in Scopus. With its intuitive interface, Scopus offers the option to focus solely on peer-reviewed material, includes more journals and provides better interdisciplinary field coverage compared to alternatives such as the Web of Science (i.e., Pauwels *et al*., 2024; Wongyai *et al*., 2024; Zhang et al., 2023).

Boolean operators were used (i.e., "aviation", "air traffic" and "airline") along with variations ("systematic literature review" OR "systematic review") at the fields of title and all fields, interchangeably (see bottom of Figure 2). The language of the search was limited to English but there was no restriction in the time frame. The combined results of each search returned 484 records. Third, a complementary search was conducted beyond peer-reviewed publications using Google Scholar (e.g., Muecklich et al., 2023; Papavasileiou & Stergiou, 2024). The first 100 results were examined using the same keywords, time frame and language.

2.2 Selection process

The screening process involved 588 publications, with 125 duplicates removed. The first two authors did the initial relevance screening. The third author resolved any disagreements and made the final inclusion decision. At the title/abstract level, we found 401 publications to be irrelevant. Three were not retrievable (see Figure 2). We read the remaining 59 publications in full against the eligibility criteria. This process found six studies that their titles initially indicated were relevant. Upon closer examination, they did not focus on air transport (see Appendix A). For example, Pantelaki and Papatheodorou's (2022) review of business aviation includes only four relevant articles in "crew related topics". Furthermore, three studies focused on military operators and were not included (Chapleau & Regn, 2022; Knapik & Steelman, 2016; Newman et al., 2017). By contrast, Ehlert et al.'s (2021) systematic review of stimulant use focused on both civilian and military aviation and was as such deemed eligible for inclusion (see Appendix A). In the same vein, although Terenzi et al. (2022) provide a review of rostering in air traffic control, the focus has been on providing comprehensive guidance using the narrative paradigm rather than providing a systematic review of the relevant literature.

Table 1 Evidence synthesis for the systematic reviews of human operators in air transport

	RQ1: Context		*RQ2: Method*					*RQ3: Thematic*	
Study	***Source***	***Discipline***	***Guideline***	***Language***	***Database***	***N***	***Period***	***Subject***	***Topic***
Ackland et al., (2022)	AMHP	Medicine	PRISMA	English	Scopus, EMBASE, PubMed, PsycINFO	58	1999-2021	Pilots	Mental Health
Bendak & Rashid (2020)	IJIE	Ergonomics	PRISMA	English	ScienceDirect, PubMed, ProQuest, SafetyLit.	100	2003-2018	Pilots	Fatigue
Bendtsen et al., (2021)	EH	Environmental Health	WG	NR	N/A	N/A	N/A	Airport employees	Occupational risks
Ciptomulyono & Dewi (2021)	CP	Engineering	WG	English	Scopus	34	1978-2020	Air traffic controllers	Workload
Co & Kwong (2020)	CBC	Medicine	PRISMA	NR	PubMed, Cochrane, EMBASE, & CINAHL	12	1995-2018	Flight attendants	Cancer (Breast)
Cross et al., (2023)	TVCG	IT	PRISMA	English	Scopus, WoS, Proquest	39	2000-2020	Pilots	Training
Ebrahim et al., (2023)	IJAP	Psychology	PRISMA	English	WoS, PsycINFO, OVID, EMBASE, Scholar	16	1985-2021	Pilots	Risk assessment
Ehlert & Wilson (2021)	IJAP	Psychology	PRISMA	English	PubMed, PsychINFO, SPORTSDiscus, WoS	20	1994-2018	Aviators	Stimulant use
Grindley et al. (2024)	TPT	Transportation	PRISMA	NR	Scopus, WoS, ScienceDirect	52	2012-2022	UAS operators	Training
Harris et al., (2022)	FPH	Public health	PRISMA	English	ScienceDirect, Taylor and Francis Online, SAGE, Springer, EBSCOhost	10	1995-2014	Pilots	Violation
Havinga et al., (2017)	Safety	Safety	PRISMA	English	Scopus, WoS, ScienceDirect	42	1988-2015	Air traffic controllers	Training
Hayes et al. (2021)	STE	Environmental Health	PRISMA	English	Scopus, WoS, ScienceDirect	43	1998-2020	Pilots & Cabin Crew	Occupational risks
Huster et al., (2014)	IAOEH	Environmental Health	Cochrane	German & English	PubMed, EMBASE, NCBI	10	1990-	Pilots	Occupational risks

							2004		
Lawson et al (2017)	AMHP	Medicine	Little et al (2008)	English	PsycInfo, PubMed, DTIC	73	2000-2015	Pilots & Cabin Crew	Training
Lazure et al., (2020)	IJAP	Psychology	Thomas (2001)	English	Scopus, WoS, Google Scholar	20	1985-2017	Flight instructors	Training
Liu et al (2016)	JTM	Medicine	MOOSE	NR	PubMed, EMBASE	10	1995-2015	Flight attendants	Cancer (Breast)
Liu et al. (2018)	CHN	Medicine	PRISMA	NR	PubMed, Cochrane	8	1996-2014	Pilots & Cabin Crew	Cancer (Thyroid)
Marete et al., (2022)	CARI	Aviation	PRISMA	English	Scopus, ERIC, Proquest, Compendex	22	2004-2020	Aviators	Gender gap
Marques et al., (2023)	IJAP	Psychology	Cochrane	English	Scopus, WoS, ScienceDirect.	75	1990-2020	Pilots	Training
Marqueze et al., (2023)	IJERPH	Public health	PRISMA	Portuguese, English, & Spanish	Scopus, WoS, PubMed, Cochrane	36	1997-2020	Pilots & Cabin Crew	Organizational Risk Factors
Melin & Lång (2024)	IJAP	Psychology	PRISMA	English	WoS, PubMed, PsycINFO	4	2012-2019	Pilots & Cabin Crew	Mental Health
Miura et al., (2019)	BJD	Medicine	PRISMA	NR	Scopus, EMBASE, PubMed, CINAHL,	12	1970-1990	Pilots & Cabin Crew	Cancer (Skin)
Omran (2023)	Thesis	Public health	PRISMA	NR	PubMed, Embase, PsycINFO, Cochrane	51	1996-2021	Pilots & Cabin Crew	Occupational risks
Osunwusi et al., (2020)	IJAAA	Aviation	WG	NR	N/A	13	1993-2019	Air traffic controllers	Occupational risks
Pagnotta et al., (2022)	Ergonomics	Ergonomics	PRISMA	English	WoS, PsycINFO, PubMed, PSICODOC	39	1980-2021	Air traffic controllers	Workload
Pasha & Stokes (2018)	FP	Medicine	PRISMA	English	PubMed, EMBASE, PsycINFO	20	1985-2017	Pilots	Mental Health
Raslau et al. (2016)	AMHP	Medicine	PRISMA	NR	PubMed, OVID	9	1996-	Pilots	Cancer (Prostate)

							2012		
Russo et al., (2023)	IJERPH	Public health	PRISMA	English	Scopus, WoS, PubMed, Cochrane	35	1996-2020	Pilots & Cabin Crew	Occupational risks
Sanlorenzo et al. (2015)	JAMAD	Medicine	PRISMA	English	Scopus, WoS, PubMed	19	1990-2013	Pilots & Cabin Crew	Cancer (Skin)
Schmid & Stanton (2020)	IJAP	Psychology	WG	English	Scopus, Google Scholar	75	2007-2019	Cabin Crew	Reduced-crew operations
Shaker & Al-Alawi (2023)	CP	Engineering	PRISMA	English	ScienceDirect, Google Scholar	10	2017-2019	Pilots	Training
Silva et al (2022)	IRAE	Engineering	PRISMA	English	ScienceDirect, ACM Digital Library	31	1995-2022	Pilots	Mental Health
Suarez et al., (2024)	SS	Safety	PRISMA	English	WoS	5	1993-2006	Air traffic controllers	Workload
van Weelden et al. (2022)	AE	Ergonomics	PRISMA	English	Scopus, PubMed	54	2000-2021	Pilots	Training
Wang et al. (2024)	Sensors	IT	PRISMA	English	Scopus, WoS, PubMed	29	2000-2023	Pilots	Workload
Weinmann et al. (2022)	JOEM	Medicine	PRISMA	English	PubMed, EMBASE	6	1995-2015	Flight attendants	Cancer (Breast)
Wen et al (2023)	IJERPH	Public health	PRISMA	English	Scopus, EMBASE, PsycINFO, OVID	27	1990-2021	Pilots & Cabin Crew	Fatigue
Wilson et al (2022)	IJERPH	Public health	PRISMA	English	WoS, PubMed, CINAHL, PsycINFO, SPORTDiscus	48	1990-2022	Pilots	Occupational risks
Wirawan et al (2018)		Medicine	G-I-N	English	PubMed, EMBASE, OVID	45	2001-2014	Pilots	Risk assessment
Yan et al (2024)	IJAP	Psychology	PRISMA	English	Scopus, ScienceDirect WoS, ProQuest, EBSCOHost, ARC	13	1992-2018	Pilots	Violation

Yanikoglu et al (2023)	BK	Aviation	Xiao & Watson (2019)	English	N/A	21	2000-2022	Aviators	Gender gap

Note: **AMHP** = *Aerospace Medicine and Human Performance;* **IJIE** = *International Journal of Industrial Ergonomics;* **EH** = *Environmental Health;* **CBC** = *Clinical Breast Cancer;* **TVCG** = *IEEE Transactions on Visualization and Computer Graphics;* **IJAP** = *The International Journal of Aerospace Psychology;* **TPT** = *Transportation Planning and Technology;* **FPH** = *Frontiers in public health;* **SCE** = *Science of the Total Environment***;** **IAOEH** = *International archives of occupational and environmental health*; **JTM** = *Journal of Travel Medicine;* **CARI** = *The Collegiate Aviation Review International;* **CHN** = *Cancers of the head & neck;* **IJERPH** = *International Journal of Environmental Research and Public Health;* **BJD** = *British Journal of Dermatology;* **IJAAA** = *International journal of aviation, aeronautics, and aerospace;* **FP** = *Frontiers in psychiatry;* **JAMAD** = *JAMA Dermatology;* **IRAE** = *International Review of Aerospace Engineering;* **SS** = *Safety Science;* **JOEM** = *Journal of Occupational and Environmental Medicine;* **AE** = *Applied Ergonomics;* **CP** = Conference proceedings; **BC** = Book chapter; **NR** = No restrictions; **WG** = Without guidelines; **G-I-N** = G-I-N International Guideline Library; **WoS** = Web of Science; **ARC** = Aerospace Research Central; **DTIC** = Defence Technical Information Canter

2.3 Data extraction

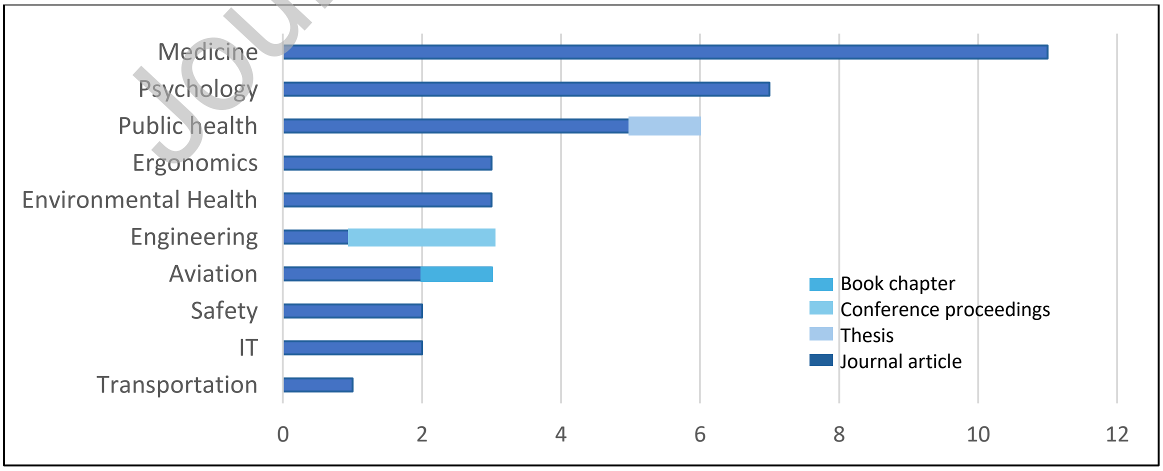
We transferred the data from the 41 included reviews into a Microsoft Excel document. The standardized extraction matrix comprised of three spreadsheets, per the three review questions (See Table 1). First, we extracted the contextual elements including the source of the publication (e.g., journal article, conference proceedings), the discipline (e.g., psychology, public health) and the affiliation of each author. Second, we classified the methodological approach including the specific guidelines followed (e.g., PRISMA, Cochrane), the electronic database used, the inclusion/exclusion criteria for the language (e.g., only English) and the type of literature (e.g., only peer-reviewed) as well as the number of studies included in the review and the period covered. Third, we gathered the thematic elements including the topics (e.g., training, mental health) and the subjects under review (e.g., pilots, cabin crew).

3. Evidence synthesis

3.1 Contextual synthesis

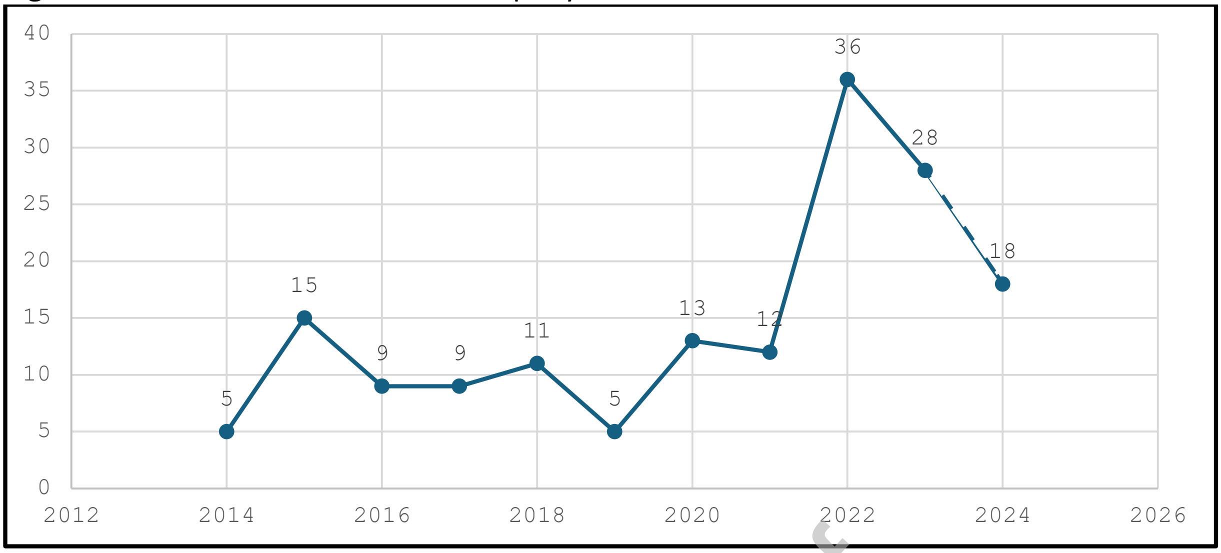
The contextual synthesis reveals a multidisciplinary stream of research, with medicine topping the list (27%), followed by psychology (17%) and public health (15%). Figure 3 shows that 90 percent of these systematic reviews published in academic journals. There also two systematic reviews in conference proceedings (Ciptomulyono & Dewi, 2021; Shaker & Al-Alawi, 2023), a book chapter (Yanikoglu et al., 2023), and a thesis (Omran, 2023).

Figure 3 – Publication channels per discipline and source



Source: *own elaboration*

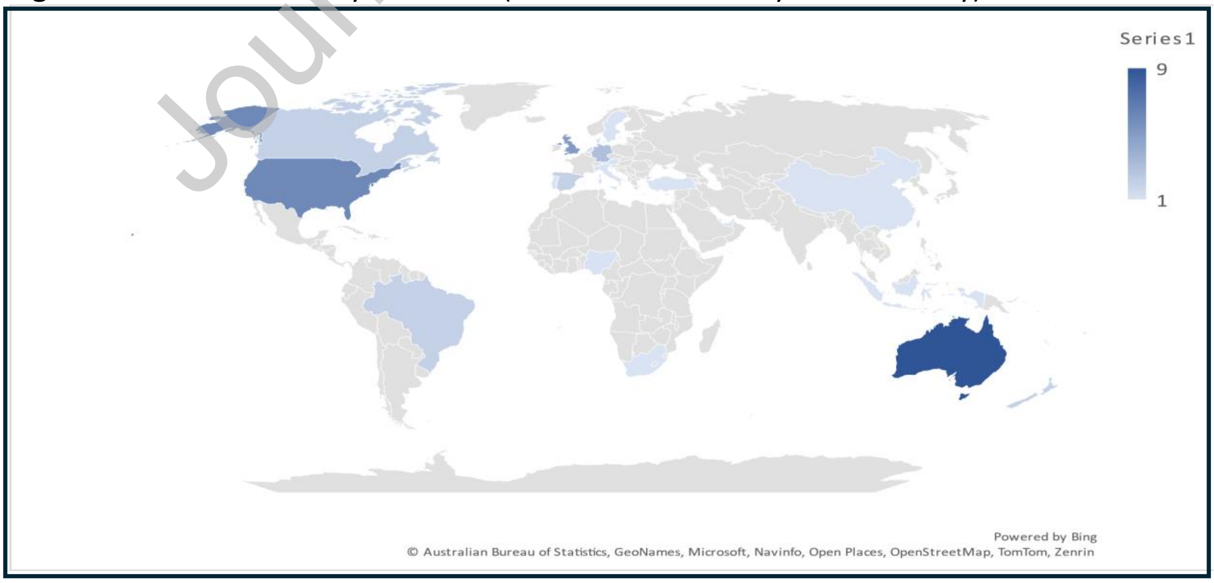
Figure 4 – Number of fist-time authors per year



Source: *own elaboration;* **Note:** *The data for 2024 refer up to August 2024.*

Figure 4 illustrates the number of authors per year. It uses the year a contributor's name first appeared in our database, which is in chronological order (see Ritz et al., 2016). This approach ensured that each researcher was only considered once. It provided a clear picture of the stream's growth in unique contributors over time. Like the rise in publications, new authors remained low until 2019. They totalled 54. The 2015 peak, with 15 co-authors, is due to one paper (see Sanlorenzo et al., 2015). From 2020 to August 2024 – the last entry in our database – the numbers almost doubled with 107 new authors. There is clear evidence of a growing stream of researchers. It now totals over 160.

Figure 5 – Authors' country affiliation (based on the country the university)



Source: *own elaboration*

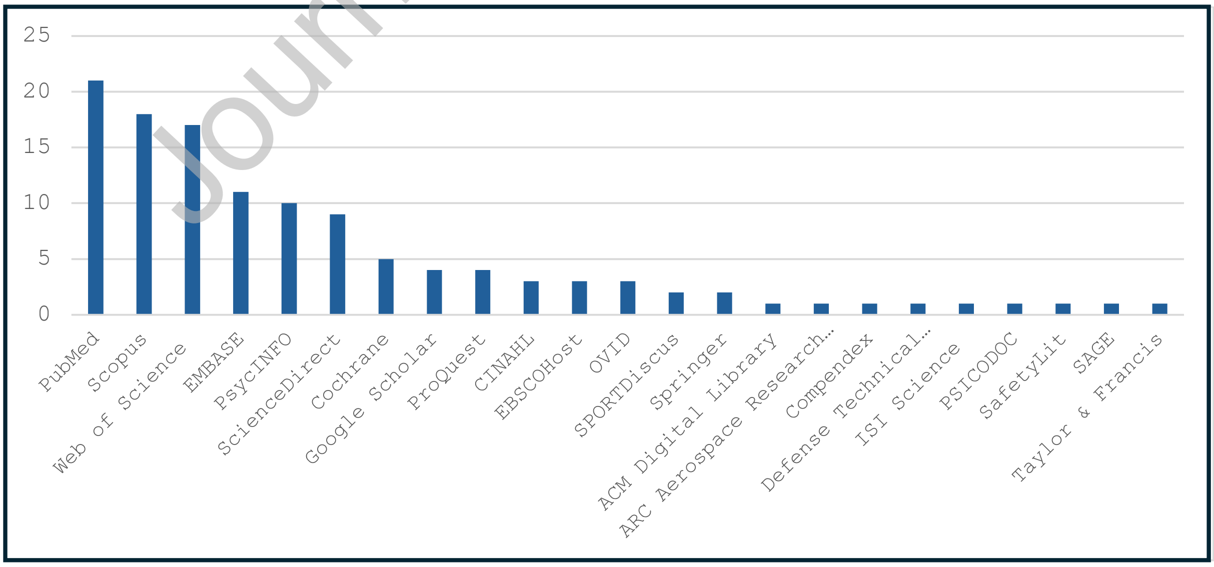
Figure 5 shows the distribution of author affiliation. It focuses on the country of the universities. The 41 systematic reviews on this topic come from 23 countries. The highest number of outputs (nine) is from Australian universities. The US has six outputs, the UK has five outputs, and Germany has three outputs. Universities from Brazil, Canada, New Zealand, and Spain were included, with two outputs each. Universities from 15 more countries contributed one output each.

3.2 Methodological synthesis

In terms of methodology, 90 percent of the systematic reviews followed specific guidelines (Table 1). PRISMA was the most used, with 30 reviews. Huster et al., (2014) and Marques et al., (2023) conducted their systematic review based on the Cochrane Guidelines (see for example Dewey & Drahota, 2016). The systematic review by Liu et al. (2016) was part of a meta-analysis of breast cancer in flight attendants. The researchers followed the Meta-analysis of Observational Studies in Epidemiology (MOOSE) guidelines.

The 41 systematic reviews used 23 electronic databases to find eligible publications (see Figure 7). The most favoured were PubMed (*n* = 20), Scopus (*n* = 18), and Web of Science (*n* = 17). In most cases, a multi-source strategy was used with at least three databases (75%). Additionally, nine publications (21%) did not impose language restrictions in their search. The remaining systematic reviews were mostly limited to English-language publications.

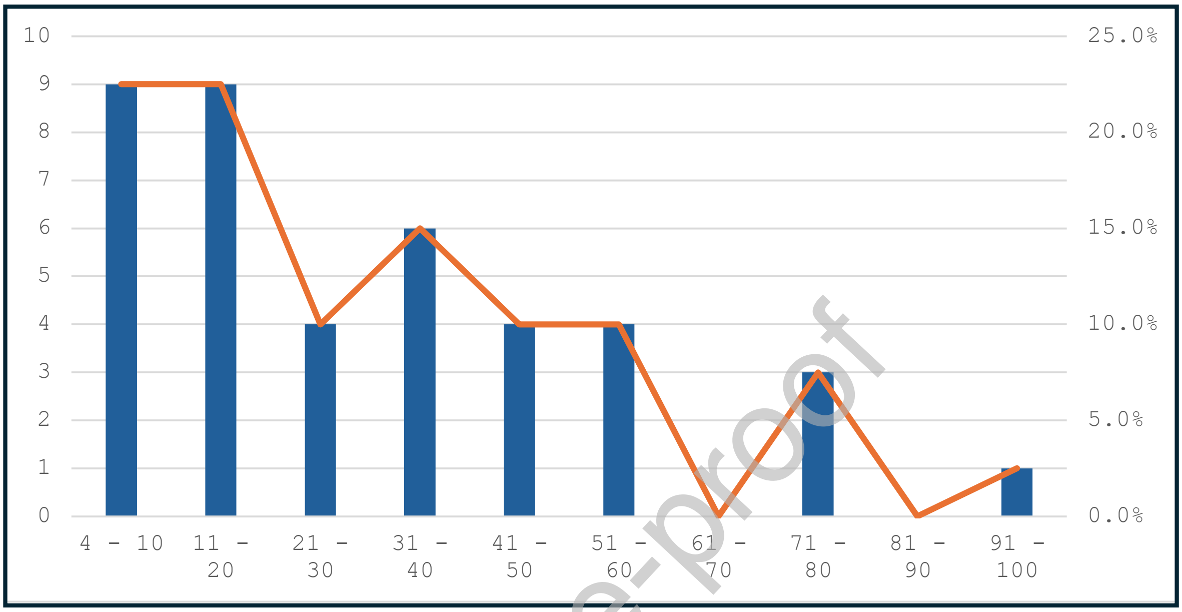
Figure 6 – Electronic databases used for literature identification



Source: *own elaboration.*

Based on the above methodology, the number of studies under review, ranged from four (e.g., Melin & Lång, 2024) to 100 (e.g., Bendak & Rashid, 2020). Most of the systematic reviews comprised from four to 20 studies (45%) whereas the average was 31 studies. The period covered in this stream of research, spans from three years (e.g., Shaker & Al-Alawi, 2023) to 42 years (Pagnotta et al., 2022) with an average period of 23 years.

Figure 7 – Number of studies included in systematic reviews



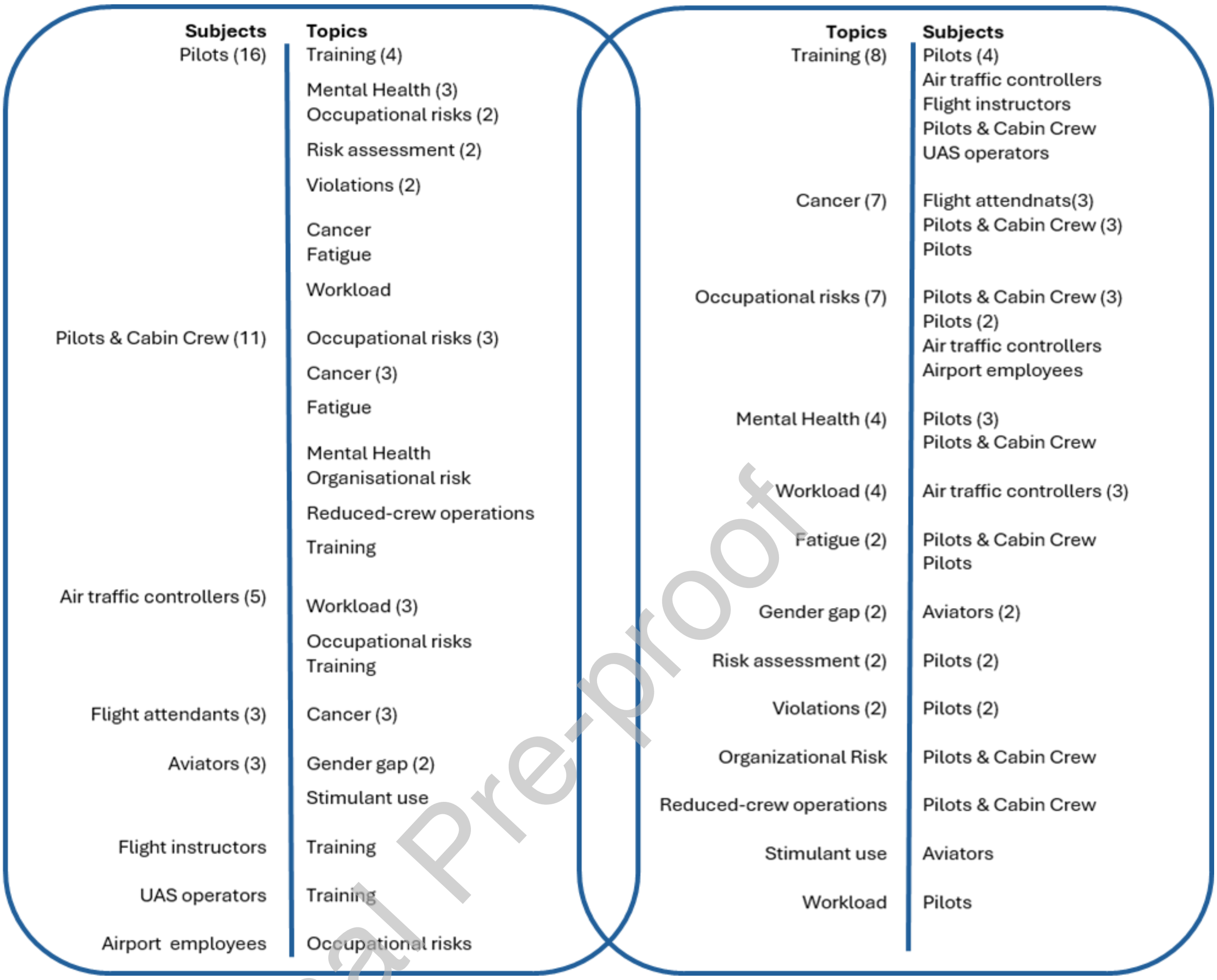
Source: *own elaboration.*

3.3 Thematic analysis

Figure 8 provides a schematic representation of the areas of interest. The left side presents the distribution of the findings based on the subjects and the right side based on the topics.

In relation to the subjects of interest, the human operators, eight categories were identified. Pilots were the most frequent focus (39%), followed by aircrew, which includes pilots (24%). Air traffic controllers were also a significant subject of study (e.g., Ciptomulyono & Dewi, 2021; Havinga et al., 2017; Pagnotta et al., 2022; Osunwusi et al., 2020; Suarez et al., 2024). Other categories included flight attendants (e.g., Co & Kwong, 2020; Liu et al., 2016; Weinmann et al., 2022), airport personnel (Bendtsen et al., 2021), flight instructors (Lazure et al., 2020), and aviation and aerospace students (Marete et al., 2022).

Figure 8 – Thematic synthesis based on the subject and topic of the systematic reviews



Source: *own elaboration*.
Note: *The numbers within the parentheses represent the number of systematic reviews focused on the specific topic/subject.* In addition, the topic of interest was mostly related to training (20%), cancer (17%), occupational risks (17%), mental health (10%) and workload (10%). Emphasis was also placed on fatigue (e.g., Bendak & Rashid, 2020; Wen et al., 2023), violations (e.g., Suarez et al., 2024; Wang et al., 2024), gender gap (e.g., Marete et al., 2022; Yanikoglu et al., 2023), risk assessment (e.g., Ebrahim et al., 2023; Wirawan et al., 2018), the use of stimulants (Ehlert & Wilson, 2021) and reduced crew operations (Schmid & Stanton, 2020).

4. Main trends

The above analysis helps us find key features from the systematic reviews of human operators in air transport.

- The global growth of the research community seems key. It drives the rise in systematic reviews on this topic. Until 2019, research was linked to universities in 7 countries:

Germany, Italy, China, the USA, Australia, New Zealand, and the UK. From 2020 to August 2024, that number more than tripled, reaching 23 countries on all six continents.

- Systematic reviews on this topic are a multidisciplinary research stream. They include medicine, public health, psychology, ergonomics, engineering, IT, safety, and the environment.
- The systematic reviews in this meta-review had high methodological transparency. They were detailed. They disclosed the steps, choices, and judgments made during the studies (Aguinis et al., 2018, p.84). This shows in the strict adherence to guidelines and the use of multi-source searches.
- The 41 systematic reviews in this meta-review include over 1000 publications. They cover 45 years, from 1978 to 2023.
- The focus of the systematic reviews was mostly on those responsible for the operation of the aircraft meaning pilots and cabin crew and their health – physical and mental

5. Future directions

5.1 Systematic review of airport ground operators

This meta-review found a significant gap. There are no systematic reviews on airport ground human operators. With passenger traffic and airline revenues up, the air transport industry faces key challenges in staffing and efficiency, especially at airports (IATA, 2023; Biedermann et al., 2024; Under & Gerede, 2024). Pilot and airline crew workforce issues are high-profile. But they are not the only concerns. Airports worldwide have struggled to staff various roles. These include ground handling and airport security (Sobieralski & Hubbard, 2023).

Future systematic reviews should explore specific research questions such as: What affects job satisfaction and performance among airport ground staff? How do automation and AI affect the roles of these operators? Also, research should investigate how to manage these workforce challenges post-pandemic. It should look at the implications for future operations. A mixed-methods approach would help us understand these dynamics. It would combine survey data with insights from case studies. Wandelt & Wang's (2024) review of the airport ground workforce dilemma may help in this direction. It details the challenges of solving the issue.

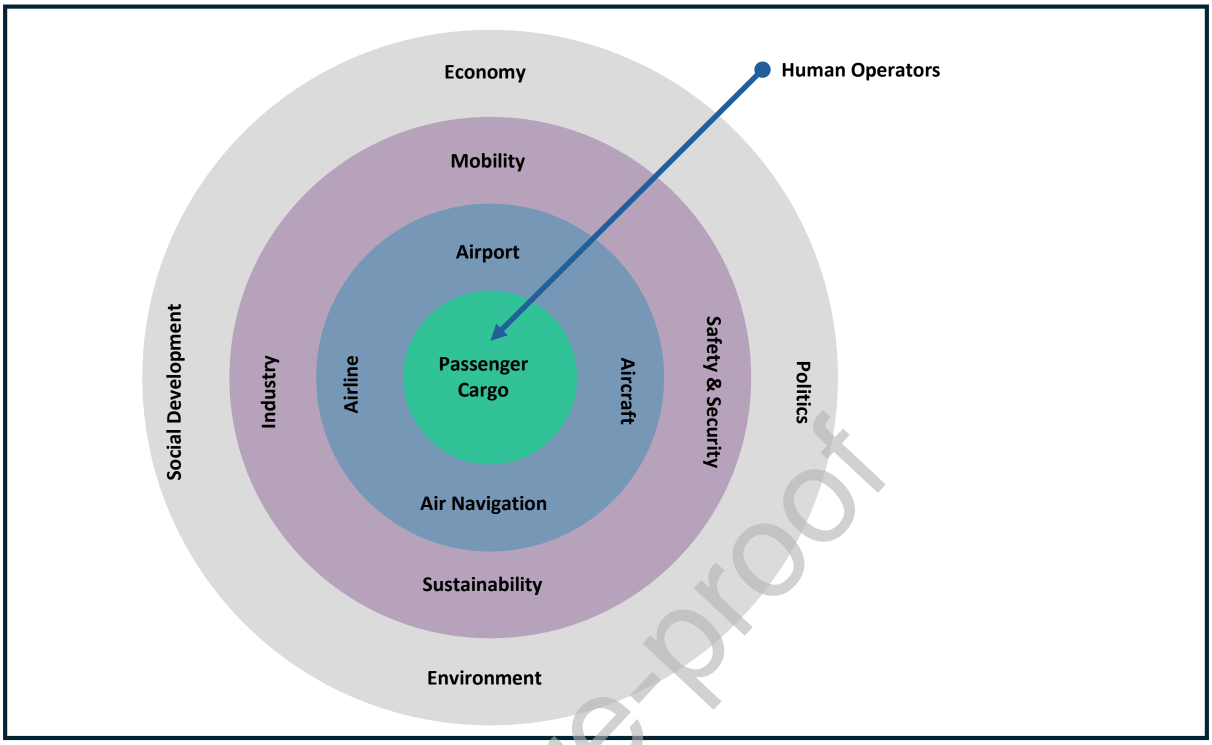
5.2 Systematic review of work attitudes, behaviours and skills of human operators

The International Air Transport Association (IATA, 2018) has long called for research on the skills needed by the future aviation workforce. Their "*Future of the Airline Industry 2035*" report stresses the need to prepare for major shifts in work. These are driven by technology and changing values. Our meta-review finds a gap in systematic reviews on work attitudes, behaviours, and skills in aviation. This is despite those calls. The different generations of human operators are important. Their attitudes, behaviours, and skills matter. For example, Francis (2024) reports that the Air Line Pilots Association (ALPA) has four generations working side by side: Baby Boomers (15%), Generation X (43%), Millennials (37%), and Generation Z (5%). It is crucial to understand their difference. It will help the industry to "engage and communicate with members, bridge generational divides, and foster unity within its pilot community" (Francis, 2004).

5.3 Placing human operators at the core of air transport system

Future reviews should also aim to advance theory in the field. The current literature provides valuable data. But we need studies that challenge existing theories or propose new frameworks. Including human operators in systems theory for air transport could optimise both human and tech resources. It may offer new ways to do this. For example, Schmitt and Gollnick's (2016) book entitled "*Air Transport System*" includes a comprehensive system of air transport and its environment (see Figure 9). However, the authors note that, "to limit the focus of this book, these stakeholders [human operators] do not receive explicit consideration" (p.2). Future reviews should include the human operators, as proposed. Cargo and passengers are the air transport system's occupants. Reviews that develop or refine such theories would help academics. They would also guide industry stakeholders.

Figure 9 Air transport system and its environment



Source: *Developed from Schmitt & Gollnick (2016)*

6. Conclusion

The findings of this meta-review have important theoretical and practical implications. The integration of human operators into broader systems theory (Figure 9), as this review proposes, offers a new view on optimising both human and technological resources in air transport systems. This conceptual contribution can serve as a foundation for future research. The aim should be to test new frameworks. They should better reflect the complexities of human factors in air transport. This needs testing via case studies and/or by working with sociology or ergonomics.

The gaps found, like the need for research on airport ground operators and the changing skills of different generations in aviation, highlight a clear agenda for future studies. Priority should be given to longitudinal studies or large-scale surveys of these gaps. The post-pandemic context demands a look at its long-term effects on human operators' adaptability and mental health. Also, closing these gaps is vital for air transport policy and practice. This is especially true as it recovers from the pandemic and readies for future challenges. To improve the use of these findings, we need to (a) engage stakeholders by co-developing actionable policy frameworks with them and (b) present detailed scenarios that bridge theory and practice.

However, these findings are not without limitations, and we must acknowledge them. First, we selected systematic reviews based on specific criteria. While necessary, this might have biased the scope and focus of the included studies. Also, the focus on English publications may have excluded relevant non-English studies. This could limit the findings' comprehensiveness. Future research can address the above by adopting multilingual approaches, leveraging machine translation, and visualizing trends through interactive tools. As a case in point, a small but growing body of work begun to recognise the benefits of exploring literature beyond English publications. This stream of research incorporated more languages, like German (see Huster et al., 2014), Portuguese, and Spanish (see Marqueze et al., 2023).

Overall, this meta-review contributes empirically, conceptually and methodologically and to air transport research. Empirically, it is the first to synthesise all systematic reviews on human operators in air transport. It covers a period of 10 years, from 2014 to 2024. During this time, 41 systematic reviews were published on the topic. The findings illustrate key trends in authorship, publication channels, methods, and areas of interests. This helps to understand how this research stream has evolved. Moreover, it shows the growing interest in human operators in air transport systems.

Methodologically, it provides full details of the steps, decisions, and judgments made during the review. The PRISMA 2020 flow diagram, illustrates the search and selection processes, from the number of publications identified in different sources (e.g., prior reviews, SCOPUS and Google Scholar) to the number of studies included in the review. Appendix A offers a clear documentation of the screening process conducted against the set of the predefined eligibility criteria. Furthermore, Appendix B, illustrates how each item of the PRISMA 2020 checklist has been addressed from the introduction and methods to the results and discussion sections of the meta-review report. This enhances the outcome's rigour and transparency. Field scholars planning a systematic review will benefit from timely advice on how to design, execute and report the process.

Conceptually, this meta-review argues for a broader view of air transport. It should include human operators at the core, along with passengers and cargo (see Figure 9). This will enhance our understanding of the field and reflect the importance of human operators. The air transport system relies on human operators who directly contribute to its operations, such as flights, air navigation, cargo and ground handling, and maintenance. Notwithstanding the influence of technology and technology substitution within the air transport operations, the industry remains largely reliant on the inputs of the human operators.

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Declaration of interests

☒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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