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# Did research address the pandemic, epidemic or infectious risk in public transport scenarios? A systematic review to rethink future environmental implications for mobility.

David Milesi-Gaches<sup>1\*</sup>

<sup>1</sup> Department of Life & Environmental Sciences, Faculty of Science & Technology, Bournemouth University, milesi.david@gmail.com

\* Corresponding author, e-mail: [milesi.david@gmail.com](mailto:milesi.david@gmail.com)

## Abstract

Public transports were strongly impacted by the Covid-19 pandemic through, for example, networks shut down, or lockdown and distancing measures. Transport scenarios are helpful tools on which policies, development and management strategies are built. To see if we can still rely on pre-2020 scenarios in a post-pandemic world, it is important to explore if the epidemic, pandemic or infectious (EPI) risk was addressed or discussed. Hence, this paper proposes a systematic review to explore how the EPI risk and health are discussed in transport scenarios and transport scenario guidance documents. Both scientific and grey literatures were reviewed, through 17 search engines, with French and English keywords. Data were then processed through a Factor Analysis of Mixed Data (FAMD). The sample of 110 documents underlines a poor consideration for the EPI risk, with only 4 papers addressing, 7 mentioning and 37 indirectly mentioning the EPI risk, despite an important consideration for health (101 documents discussed health, with an average number of 3.45 health topics addressed). When discussed, the EPI risk is always addressed through the prism of health although it is recognized as a global disruptor for the whole society. Indeed, the more health topics are addressed, the more it is likely to find the EPI risk addressed in public transport scenarios or guidance documents.

## Keywords

public transport, scenario, infectious risk, pandemic, environment

## 1 Introduction

Mobility is essential, transport became critical. According to the UK Office for National Statistics, transport is, in 2019, the largest household expense (13,7%) with an average of £80.20/week. Indeed, transport help people to participate in life, to access jobs, services, education, healthcare or leisure activities and tourism (Hickman et al. 2017; Berg and Ihlström, 2019). Obviously, most urban houses face roads rather than walkways or cycling lanes (Hickman et al. 2017). Car ownership re-structured our societies, thus making sometimes exhausting to travel by other transport means (e.g., intermodal passenger transport, lack of transports in some areas, etc.) (Stanley and Stanley, 2017).

However, transport also plays a crucial role in the global energy use and Greenhouse Gas (GHGs) Emissions, and consequently, is critical for both health and the environment (European Commission. Joint Research Centre, 2017). Transport conditions people exposure to pollutants (environmental injustice) and fosters, or reduces, sedentariness depending on the transport mean used (Gaffron, 2012; Marmot and Wilkinson, 2005). Beyond energy use, and then resource depletion or GHGs emissions, the environment also suffers from threats induced by most transport means: land-use change, noise, biodiversity

disturbance, waste, rare-earth elements consumption, etc. (Sharp and Jennings, 1976). But, should we look to each transport mean in the same way?

When looking to the future of mobility, electric cars could for example play an important role to reach a 100% renewable energy system. Nevertheless, such system would require millions of electrified parking places, recharging networks and to develop an electric grid like it has never been produced (Garcia-Olivares et al. 2018). That, without solving congestion or resource depletion issues. Indeed, rare-earth elements (e.g., lithium) still require alternatives (Chu and Majumdar, 2012). Despite further efforts and technology improvements remain necessary (e.g., biofuels, tire design, light-weight material, etc.), a 100% renewable energy system could not see the light of day without the increase of public transports (Chu and Majumdar, 2012; Garcia-Olivares et al. 2018). Shared and public transports often reach a better energy and space efficiency, owing to their increased capacity. While 100% occupancy rate in buses or trains will lead to a lower CO<sub>2</sub> rate per passenger than empty cars, comparison of transport means remains dependent on the vehicle fill rate (Table 1).

**Table 1** Carbon emissions per passenger (Amended from TUMI, 2019a)

| Vehicle     | Passenger number            | Carbon emission (g/pkm) |
|-------------|-----------------------------|-------------------------|
| Aircraft    | 88 (average occupancy rate) | 285                     |
| Large car   | 1.5                         | 158                     |
| Small car   | 1.5                         | 104                     |
| Two-wheeler | 1.2                         | 72                      |
| Bus         | 12.7                        | 68                      |
| Large car   | 4                           | 55                      |
| Small car   | 4                           | 42                      |
| Train       | 156                         | 14                      |

Unfortunately, the Covid-19 outbreak acted in late 2019 as a major disruptor for almost all aspects of life. Through lockdown and distancing measures, transport suffered a historic stop and metamorphosis. Many networks simply shut down in spring 2020, while other transports, for example, some trains in France, were used for an unexpected task: conveying Covid-19 patients. The situation quickly raised many questions: will people accept to use public transport in a pandemic context? How will public transports be cleaned? How green is a train conveying one passenger every two seats? To what extent public transport Life Cycle Analysis will be impacted by new waste streams (e.g., face masks disposal), the use of millions of liters of cleaners, sanitizers, or regular lockdown measures? In 2003, people living in Hong Kong avoided using public transport during the SARS epidemic peak, before going back to their ways (Lau et al. 2003; Wang, 2014). What if the Covid-19 becomes seasonal? Will people regularly avoid using public transport? In all cases, transport impacts to the environment might be worsened by the Covid-19 pandemic.

The epidemic, pandemic or infectious (EPI) risk was recognized as a key component of sustainability. Land-use change globally fosters changes in biodiversity and increases the pandemic risk since it expands the human-wildlife interface. People's proximity with wild animals leads to a greater transmission risk of zoonotic diseases (Allen et al. 2017; Morse et al. 2012). Furthermore, emerging infectious diseases' origins are correlated with socio-economic, environmental and ecological factors (Jones et al. 2008). Pandemics increases all impacts to the environment, while impacts to the environment foster pandemics.

Within this vicious-like circle, public transports play a critical role owing to their environmental and ecological impacts. Morse et al. (2012) acknowledge this interaction by reminding that travel expand pandemics. This statement has been verified, since travel, and more

generally public transports, played a critical role in the spread of the Covid-19 (Gössling et al. 2020; Zheng et al. 2020). Thus, we could expect transport research to address both the EPI risk and sustainability issues.

In fact, the EPI risk in transport is well known and is widely acknowledged as a critical disruptor. Already in 1918, when the influenza pandemic became deadly in the US, Charles W. Berry, pointed out the importance of sanitation in the navy to avoid infections. Later, public transport was acknowledged as a key driver in the spread of epidemic/pandemic or respiratory infections, particularly air transport or migrations (Alirol et al. 2011; Colizza et al. 2017). Generally, all shared transport means participate in the spread of respiratory infections (Troko et al. 2011). Saunders-Hastings and Krewski (2016) even go so far as stating that '*mobility [...] became the primary vector of disease spread*'.

Surprisingly, the EPI risk is not always discussed, even among documents addressing transport and health interactions. For example, Khreis et al. (2019) forgot to address the EPI risk in their yet comprehensive conceptual model, which describes the health beneficial and detrimental transport factors. Meanwhile, the World Energy Council released a short document which offers guidance and encourages to strongly include the EPI risk in future work, such as scenarios, reminding that 'the world remains poorly prepared to even modest biological threats' (WEC, 2019).

Scenarios are common scientific tools often used to build strategies and advise policy-makers. Scenarios are usually developed to explore likely disruptions, impacts, events and to identify uncertainties. We might think so that the EPI risk will be massively discussed in studies exploring the future of transport. Nevertheless, the apparent unpreparedness of most transport networks during the Covid-19 peak undermines the idea of an appropriate inclusion of the EPI risk in transport predictive studies.

Then, I propose in this paper, the four following hypothesis:

- Both research and transport players poorly addressed the EPI risk in transport future scenarios and guidelines before the Covid-19 crisis,
- The EPI risk is discussed through the prism of health and not the prism of the environment,
- The EPI risk is discussed differently at local, regional and global scales,

- Perception is of critical importance in the way the EPI risk is discussed.

Therefore, the aim of this systematic review is to look if research and policies discuss the EPI risk in transport future scenarios, and how the latter risk is addressed.

This systematic review has been guided by five objectives:

- To analyse if research or transport players addressed the EPI risk in transport future scenarios and guidelines.
- To describe how the EPI risk is addressed, discussed or mentioned in transport future scenarios and guidelines.
- To describe how health is addressed in transport future scenarios and guidelines.
- To identify how the perception of transports impacts the way in which the EPI risk is discussed.
- To compare how the PIE risk is discussed at the local, regional and global scales.

## 2 Methods

### 2.1 Sample collection

Scenarios can take many forms. Here are considered as scenarios, every document which details a vision of future transports, whether it is a peer-reviewed document or, for example, a report, a PhD thesis, a presentation or a white paper. Hence, both scientific and grey literature were considered (Paez, 2017). Indeed, the literature on transports is often nourished by professional, national, regional, local or even inter-governmental institutions. In order to find the widest range of documents, keywords' sensitivity was considered by varying forms (e.g., singular, plural) (Table 2). When the function was offered, keywords were searched in titles and abstracts/executive summaries. 22 keywords were defined, in both French and English (Table 2) and were used in 17 search engines (Table 3), thus representing 334 requests. Data collection for the review was done without any restriction of time or transport mean (Gusenbauer and Haddaway, 2019).

**Table 2** Systematic review keywords

| English                  | French               |
|--------------------------|----------------------|
| future transport         | future mobilité      |
| future transports        | futur mobilité       |
| future mobility          | scénario mobilité    |
| transport scenario       | scénarios mobilité   |
| transport scenarios      | transport futur      |
| transports scenario      | transports futur     |
| transports scenarios     | scénario transport   |
| mobility scenario        | scénario transports  |
| mobility scenarios       | scénarios transport  |
| future transportation    | scénarios transports |
| transportation scenario  |                      |
| transportation scenarios |                      |

Were considered as a public transport, every transport which can be shared: cars, buses, trains, bikes, aircrafts, ships, elevators, rickshaw, car-sharing, etc. Documents discussing transport facilities (e.g., stations, urban furniture) have been considered as well as documents addressing space transportation, owing to the important contribution space transportation can have to other transport means (Comstock and Lockney, 2007). Due to their potential influence on future research, documents providing guidance on how to develop transport scenarios were also included in the scope.

**Table 3** Search engines and languages

| Engine                 | Address   | EN | FR |
|------------------------|---|----|----|
| BU Library             | <i>internal platform</i>  | X  | X  |
| HAL                    | hal.archives-ouvertes.fr  | X  | X  |
| Google Scholar         | scholar.google.com  | X  | X  |
| Microsoft Academic     | academic.microsoft.com  | X  | X  |
| CORE                   | core.ac.uk  | X  | X  |
| BASE                   | base-search.net   | X  | X  |
| Science.gov            | science.gov   | X  |    |
| Semantic Scholar       | semantic scholar.org  | X  | X  |
| Refseek                | refseek.com   | X  | X  |
| Science Direct         | sciencedirect.com   | X  | X  |
| PubMed                 | pubmed.ncbi.nlm.nih.gov   | X  |    |
| UN Digital Library     | digitallibrary.un.org   | X  | X  |
| TRID                   | trid.trb.org  | X  | X  |
| Google                 | Google.com <i>keyword+filetype:pdf</i>                          | X  | X  |
| ECDC                   | ecdc.europa.eu/en/publications-data                             | X  |    |
| WHO                    | through google.com:<br><i>keyword+site:who.int filetype:pdf</i> | X  | X  |
| The National Academies | nationalacademies.org   | X  |    |

The sample was built by screening all abstracts and summaries and reading documents which were not providing this feature. Only documents pretending to address the future of transports, or providing guidance through a general lens have been selected for further analysis. Indeed, a fuel scenario for future transports, for example, is not necessarily intended, by its restrictive nature, to address the EPI risk owing to its focus on energy,

technology or processing. Field specific, but still broad documents (e.g., transport’s health, transport for ageing people, the future of air transportation), were accepted, provided that they discuss health, passengers’ experience, or any sub-topic susceptible to discuss the EPI risk. Some documents, particularly among grey literature, were not found relevant upon inspection.

## 2.2 Documents classification regarding the EPI risk and health

Documents were classified under three categories based on how they discuss the EPI risk: addressed, mentioned, indirectly mentioned (Table 4). A document is considered to address the EPI risk regarding its own aim. A scenario addressing the EPI risk is a scenario which proposes actions, solutions, or recommendations. A scenario mentioning the EPI risk as a disruptor, without further development will be classified as ‘mentioned’. On the other hand, a guidance document which only states that the EPI risk should be addressed in future scenarios will be classified as ‘addressed’, owing to its objective which is to guide, and not to develop scenarios. I consider ‘indirectly mentioned’ to refer to a document which discusses any aspect of transportation which can foster the infectious risk (e.g., cleanliness, undefined health hazard). Terrorism can, for example, imply bacteriological weapons. Furthermore, I make the assumption that a place or a transport mean cannot be described as comfortable if it lacks of cleanliness. Hence, this review considers that discussing transports’ comfort constitutes an indirect mention to the EPI risk.

**Table 4** Documents categorization

|                      |   |
|----------------------|---|
| Addressed            | Addresses the EPI risk, offers guidance, propose solutions                      |
| Mentioned            | Mentions the EPI risk, without addressing it                                    |
| Indirectly mentioned | Mentions related issues (cleanliness, comfort, terrorism, overpopulation, etc.) |
| Not mentioned        | The EPI risk is not addressed or mentioned                                      |

Not addressing the EPI risk can be seen as more critical if a document aims to focus its discussion on transports’ health impacts. To analyze the extent to what the EPI risk is prioritized or forgotten in the discussion, the way documents discussed health related transport issues was recorded (e.g., air pollution, active transport, noise, safety) (Kjellstrom et al. 2003). Other health issues were found upon inspection, such as emergency response. Finally, further details were collected to investigate if authors who address/discuss the EPI risk meet a specific profile (e.g., authors from which countries? Local or global studies?

Companies, universities or public institutions?). All the collected data is recorded in the additional material (Appendix A).

## 2.3 Statistical analysis

Owing to the broad range of documents found, involving both scientific and grey literature, the sample was characterized with descriptive statistics. With both qualitative and quantitative data, the sample was then processed through a Factor Analysis of Mixed Data (FAMD), using R 4.0.3 (Pagès, 2004). The five dimensions analysis allowed to explore which variables explain the variation within the set of data.

## 3 Results

110 documents were selected, including 44 peer-reviewed papers and 66 grey literature documents (Figure 1). Variation between singular and plural form in keywords gave different results, particularly among grey literature documents. The use of different search engines was also beneficial since some documents were only found in one engine, while others were found through the 17 platforms.

### 110 documents

#### Peer-review



#### Grey literature



Guidance     Scenario(s)

**Fig. 1** Sample’s details

## 3.1 Did research address the EPI risk and discussed health in public transport scenarios?

Few papers address or mention the EPI risk, although more than a third mention the risk indirectly (Table 5).

**Table 5** Documents addressing or mentioning the EPI risk

|                      |           |
|----------------------|-----------|
| <b>EPI risk</b>      | <b>48</b> |
| Addressed            | 4         |
| Mentioned            | 7         |
| Indirectly mentioned | 37        |

### 3.2 Factor Analysis of Mixed Data (FAMD)

**Table 6** Variables contribution table per dimensions

|                   | 1     | 2     | 3     | 4     | 5     |
|-------------------|-------|-------|-------|-------|-------|
| Year              | 1.54  | 11.49 | 0.19  | 3.91  | 0.17  |
| H.Discussed       | 16.72 | 0.61  | 8.47  | 0.57  | 0.25  |
| Type              | 13.88 | 13.58 | 20.44 | 15.86 | 26.72 |
| Nature            | 11.99 | 2.03  | 12.92 | 0.79  | 0.01  |
| Entity            | 12.71 | 21.26 | 21.88 | 24.51 | 40.35 |
| Aim               | 0.46  | 5.7   | 1.46  | 1     | 0.92  |
| Scale             | 2.67  | 13.01 | 8.38  | 18.96 | 7.1   |
| PIE.Risk          | 1.29  | 5.74  | 0.92  | 24.69 | 19.89 |
| *HD.Air.pol.      | 7.64  | 1.07  | 6.44  | 0.01  | 3.22  |
| *HD.Safety        | 11.75 | 1.15  | 1.69  | 0.72  | 0.01  |
| *HD.Active.trans. | 7.05  | 11.18 | 0.45  | 0.15  | 0.01  |
| *HD.Noise         | 6.32  | 5.44  | 6.28  | 1.28  | 0.43  |
| *HD.Emer.resp.    | 5.54  | 3.56  | 0.11  | 6.56  | 0.18  |
| *HD.Other         | 0.44  | 4.19  | 10.37 | 0.99  | 0.74  |

\*HD for 'Health Discussed'

The 5 dimensions FAMD explains 35.91% of the dataset variation (Figure 3). The scree plot (Figure 2, A) shows that dimensions 1 and 2 explain 19.9% of variation, with dimension 1 representing 13.3%. Despite being the first variable in the dimension 1, the discussion of health in documents is extremely low in dimension 2 (Table 6, Figure 2, C, D). Across the two selected dimensions, entity and type are the most contributing variables (Figure 2, B). Beyond entity and type, the nature of the document, as well as the scale are well represented in dimensions 1 and 2, respectively. These two variables support the contribution of the entity and type variables.

The discussed topic in documents remains linked to the nature of the document itself, as well as the scale covered. Indeed, it remains unlikely to find a city council producing a white paper addressing health at the international scale.

Despite the contribution of the dimension 3 (6.1%) is roughly the same than dimension 2 (6.6%), dimension 3 was not explored further. Most contributing variables in dimension 3 being entity, type and nature, it was not relevant to include this dimension in the results (Table 6) since these variables are already addressed through dimension 1. Figure 3 shows that the more the number of

addressed health topics is high, the more the EPI is likely to be addressed, or at least mentioned.

### 3.3 Number of health topics discussed

Among the sample, 101 documents discussed health, with an average of 3,45 health topics discussed per document (Table 7, Figure 4).

**Table 7** Discussion of the EPI risk and health in the sample

| Health        |     |
|---------------|-----|
| Discussed     | 101 |
| Not discussed | 9   |

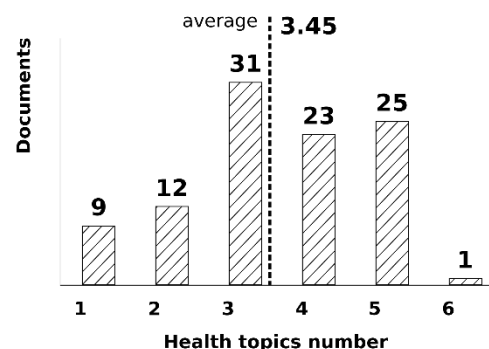
We find as main discussed health topics those described by Kjellstrom et al. (2003): air pollution, safety, active transport and noise. Safety is always discussed through the lens of infrastructures, vehicles, rules (e.g., speed limits) and behaviours. Active transport refers to inactivity, but also to pollution exposure (e.g., intermodal passenger transport requiring to walk between several transport means). Despite being more addressed in air transportation documents, noise is mentioned in all kinds of transport, as a nuisance to both humans and wildlife.

**101 documents discussed health**

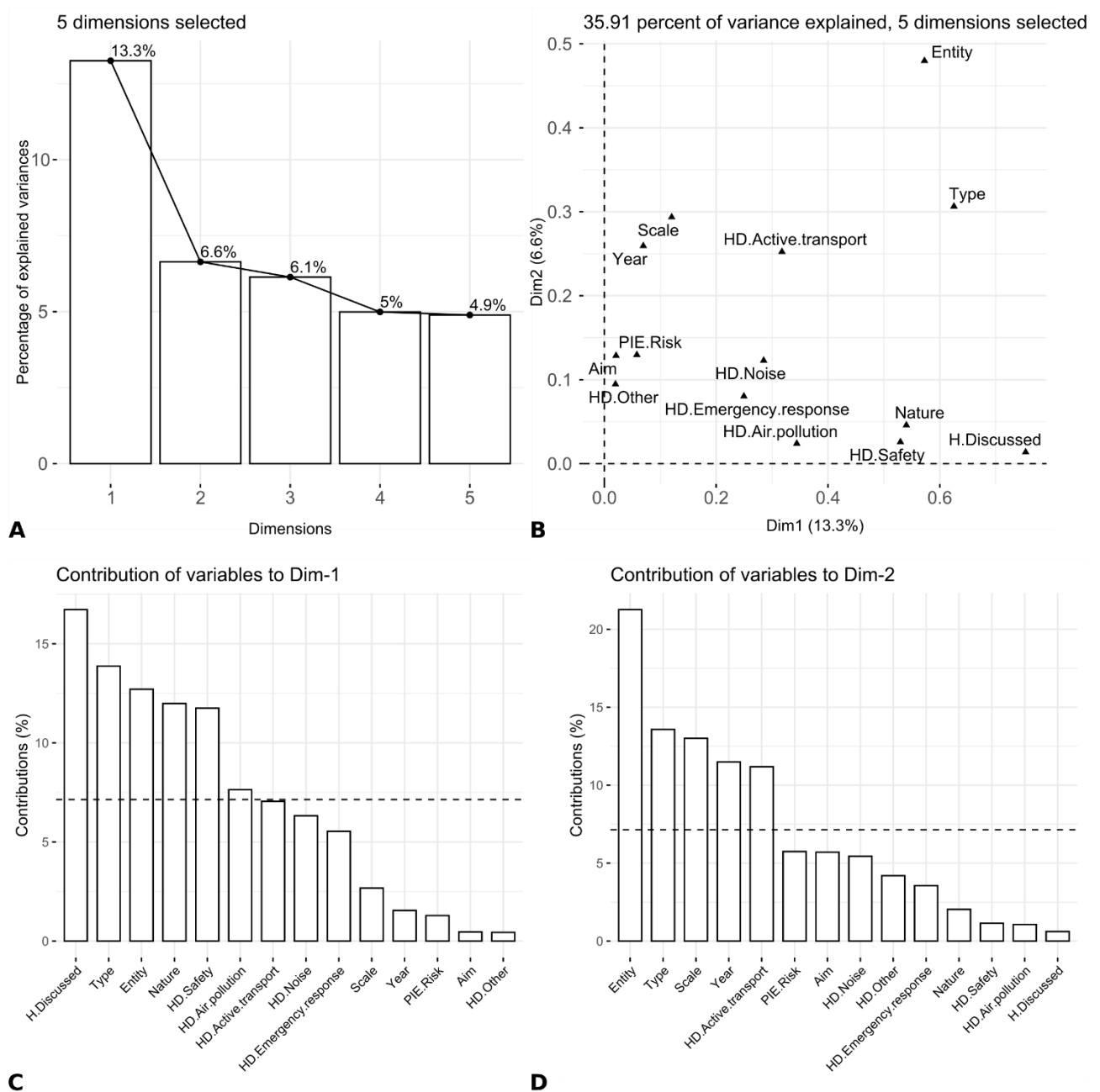
| Health topic       | Count | %  |
|--------------------|-------|----|
| Air pollution      | 91    | 82 |
| Safety             | 83    | 75 |
| Active transport   | 77    | 70 |
| Noise              | 51    | 46 |
| Emergency response | 27    | 24 |
| Other*             | 20    | 18 |

\*e.g. healthcare accessibility, healthcare cost-savings, Loss of freedom for non-motorised road use (children play), spatial justice and health, etc.

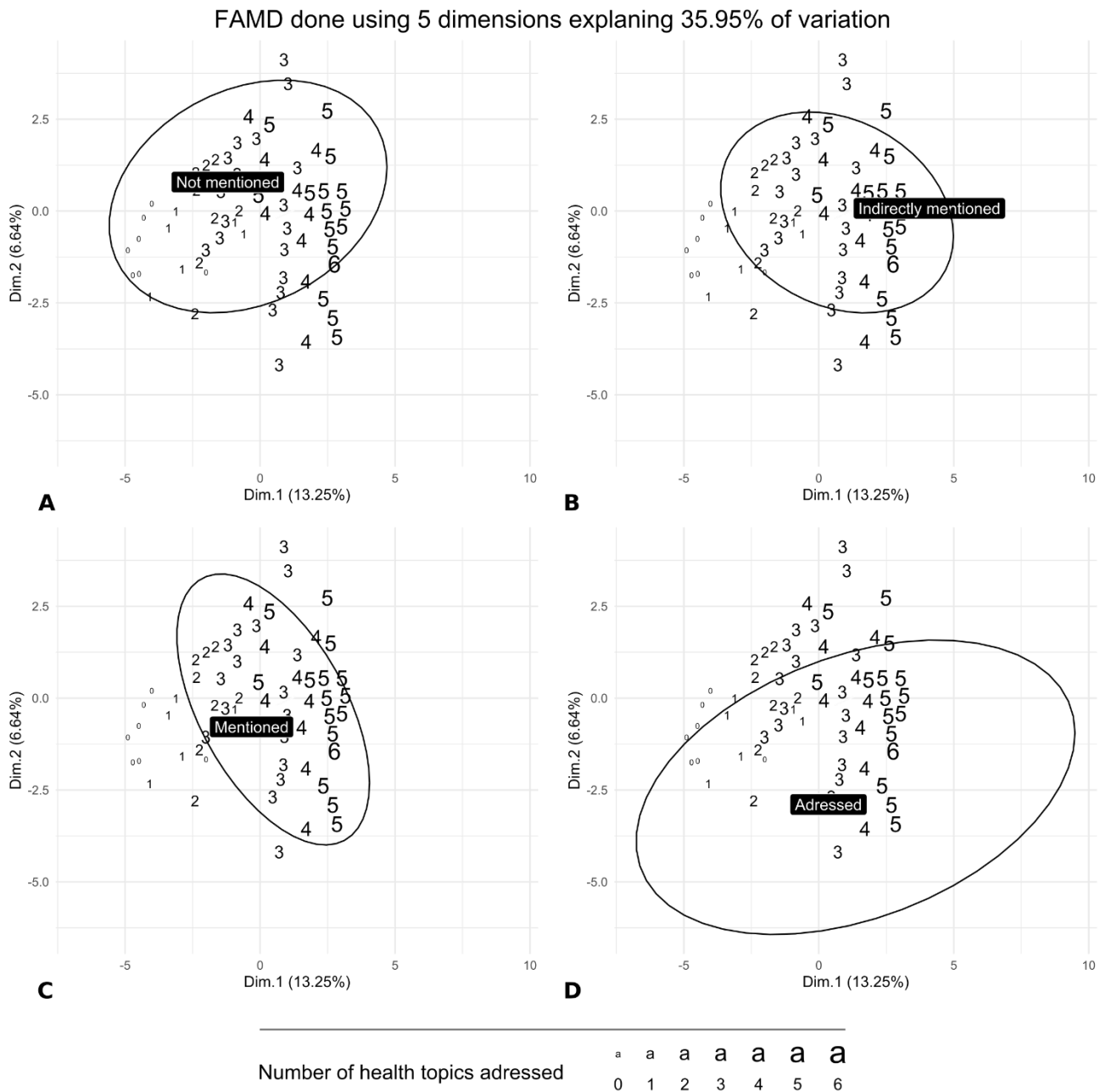
**Health topics discussed per document**



**Fig. 4** Discussed health topics



**Fig. 2** Contribution of the variables of the FAMD. **(A)** 5 dimensions scree plot showing the percentage of explained variation per dimension. **(B)** Plot of variables from dimensions 1 and 2. **(C)** Contribution of variables to the dimension 1. Dashed line shows the expected average value, if the contributions were uniform. **(D)** Contribution of variables to the dimension 2. Dashed line shows the expected average value, if the contributions were uniform.



**Fig. 3** Representation of dimensions 1 and 2 of the 5 dimensions Factor Analysis of Mixed Data, in terms of how the EPI risk was discussed. Displayed values are the number of health topics addressed per document. All four graphs show a multivariate confidence ellipse: **(A)** Documents not mentioning the EPI risk, **(B)** documents mentioning the EPI risk indirectly, **(C)** documents mentioning the EPI risk, **(D)** documents addressing the EPI risk.

Emergency response turns out to be a critical factor. Despite not being the most addressed health issue, documents which discuss this point acknowledge its criticality. Indeed, emergency response is both a health and transport issue. It embodies emergency solutions in vehicles (NSW, 2018; Transport for South East, 2019) and emergency vehicle circulation (e.g., spaced speed cushions

to allow emergency vehicles to pass without having to slow down) (Region of Peel, 2019). Important changes in public transport (e.g., pedestrian city centre) would likely impact emergency response.

Differences in the number of health topics discussed is observed according to how the EPI risk is treated (Table 8). Documents discussing the EPI risk

indirectly show the same average (3,45) than documents which discuss health (Figure 2), whether they address or mention the EPI risk. However, documents addressing or mentioning the EPI risk are clearly among documents which discuss more health topics (respectively 4,00 and 3,57).

**Table 8** Average number of health topics treated regarding the EPI risk

| EPI risk             | Average |
|----------------------|---------|
| Addressed            | 4,00    |
| Mentioned            | 3,57    |
| Indirectly mentioned | 3,45    |
| Not discussed        | 3,33    |

### 3.4 Scenario(s) versus guidance documents

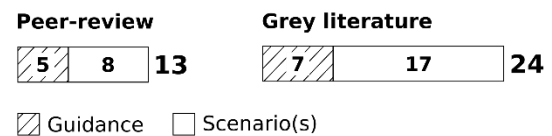
Guidance documents are likely to address the EPI risk: among the 4 documents addressing the EPI risk, 3 offer guidance. However, their aim is to define guidelines or to evaluate scenarios. To this end, a large range of transport aspects are likely to be discussed. On the other hand, the EPI risk is likely to be mentioned in scenarios, with 6 scenarios mentioning the EPI risk against one guidance document. Despite the purpose of a scenario is to explore possible paths involving specific parameters, the EPI risk remains only mentioned in scenarios, as a major disruptor, to define the boundaries of the study. For example, the Queensland Department of Main Roads and Department of Transport (2000) recognize that a *'modern Black Plague [...] would drastically alter transport future'*. Despite this clear statement, they assume not to address the pandemic risk: *'A decision was made not to base any of the scenarios on these more speculative wildcards.'*

### 3.5 Documents addressing the EPI risk

4 documents addressed the EPI risk (Table 5). Only one document is peer-reviewed (Annema and De Jong, 2011), while the three others are reports. Three documents offer guidance (Anema and De Jong, 2011; National Research Council, 2003; Tetraplan, 2009) and one develops scenario(s) (IATA, 2018). No document is found to address the local scale. However, this can be explained by a strong representation of air transportation (2 documents). On average, 4 health topics are discussed despite Annema and De Jong (2011) only address two health topics. Nevertheless, their research is specific (past scenarios evaluation) and do not imply to discuss a wide range of health topics.

Even if these documents use a specific event to start their discussion on the EPI risk (e.g., reference to

Ebola), all broaden perspectives and adopt global approaches. The company Tetraplan provides guidance on transport scenarios and identifies viruses (quoting Ebola and the bird flu) as disruptors. They also insist on 'whether [health hazards] are caused intentionally or unintentionally' (Tetraplan, 2009). Thus, referring to bacteriological terrorism. In their evaluation of past scenarios, Annema and De Jong (2011) mention the risk as a unique event like wars or 'black swans' which are often missing in 'business as usual' transport scenarios. Nonetheless, they don't discuss the emergency response issue, despite the EPI risk, particularly epidemics and pandemics, always require strong and quick responses. In its Future of the Airline Industry 2035 report (IATA, 2018), the professional association directly identifies infectious diseases and pandemics as environmental drivers of change, without referring to a specific and past event. They also acknowledge the 'greater than average' impact and uncertainty of pandemics. Then, the report develops the extent to what a pandemic can have important impacts, as a geopolitical factor, and provides recommendations.



### Topics referring indirectly to the EPI risk



\*Other: Future health outcomes (3), health hazards (1), Lasting crisis endangering security (1), human factors (2), overpopulation (3), respiratory infection (1)

**Fig. 5** Documents mentioning indirectly the EPI risk

### 3.6 Documents mentioning the EPI risk

7 documents mentioned the EPI risk (Table 5). While the ratio between peer-reviewed and grey literature documents seems balanced, it is worth to observe that two documents are written by the same company (RAND, 2013; 2015). The two documents are part of the same series, and identify 'global pandemic' as a wildcard able to 'totally redirect the paths identified', without addressing it in its reports. Three documents are less general and focus on a specific topic:

shared vehicles (Burns, 2013), tourism (Peeters et al. 2019), transport health issues (Stevenson et al. 2016).

The way the EPI risk is mentioned also differs. In Burns (2013), the EPI risk is mentioned in an illustrative manner. The author compares the number of road deaths with the impacts of epidemics. Other documents mention the EPI risk for what it is. The National Academies of Sciences, Engineering, and Medicine (2018) acknowledge transportation to have a role in *'the spread of infectious diseases.'* Peeters et al. (2019) clearly mention *'outbreaks of diseases'* as a future impact of climate change. However, they don't develop this factor in scenarios. Similarly, and despite their research article addresses health issues in transports, Stevenson et al. (2016) only mention the infectious risk (*'The ongoing challenges associated with infectious diseases in highly urbanized areas'*). However, they provide the reference to a paper addressing this issue.

Documents mentioning the EPI risk, without addressing it, do not rely on specific examples and mention the risk in a broad sense. Even *'Black Plague'* is quoted with the qualifier 'modern', thus expressing a similarity without compromising the singular character a new infection, epidemic or pandemic could have.

### 3.7 Documents indirectly mentioning the EPI risk

37 documents indirectly mention the EPI risk (Table 5, Figure 5). 13 are peer-reviewed and 24 are grey literature, including reports and one PhD thesis. The local scale is well represented in this category in the sample (16 documents), particularly the city-scale. Among the 37 documents, the EPI risk is mostly mentioned indirectly under *'cleanliness'* and *'comfort'* labels, with respectively 19 and 13 documents. Cleanliness and comfort are addressed through a passenger point of view and relate to vehicles' interior and waiting environments or facilities (e.g., City of Gold Coast, 2018; City of Vancouver, 2012; Department of Transportation and NASA, 1981; NASA, 1976, NSW, 2018, etc.). Cleanliness and comfort are also found in studies which investigate passengers' expectations (e.g., 'too dirty'), through interviews or surveys (Enoch et al. 2020; Gairal Casadó et al. 2020; ILC-UK, 2015). However, two documents mention the word 'clean' in an imprecise way, thus making it unclear to state if it refers to surfaces' cleanliness or vehicle emissions (Bilorus et al. 2012; Deloitte, 2016). One document mentions the contamination risk in a clearer manner (bacteria, microbes) but only discuss it as a risk for biodiversity through the introduction of alien species via goods transportation (AEE, 2016).

Globally, documents which mention indirectly the EPI risk explore a less numerous, but widest range of health topics, compared to documents addressing or mentioning the risk. On average, the 37 documents discuss 3,45 health topics with a large proportion of 'other' health topics (11 documents). 'Other' health topics are always very specific and address subjects such as: accelerating walkways (The Department of Transportation and NASA, 1981), the use of drones for emergency response (IAU Île-de-France, 2018) or the loss of freedom for non-motorised road use (children play) (Lyons et al. 2002). Consequently, some scenarios can provide complex, comprehensive and deep transport-related health analysis while leaving aside the EPI risk.

### 3.8 Scale

Scale contributes to 13.01% of the second dimension of the FAMD for only 2.67% in the first dimension. Within the sample, only the regional scale (continental, two or more countries) is poorly represented (Figure 6).

Scale of study

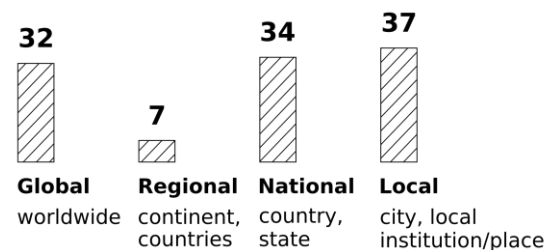


Fig. 6 Documents mentioning indirectly the EPI risk



The early years of the 21st century also saw the development of Mobility as a Service (MaaS) solutions, electric vehicles, shared fleets of bikes and cars, a profound mutation of the air transport since the 11th of September terrorist attacks and an increased concern for a sustainable future (Holguin-Veras et al. 2012; IEA, 2019). All these events encourage research to produce more transport studies.

While health is almost always discussed in all transport studies, documents addressing the EPI risk are likely to discuss more health topics compared to documents only mentioning the risk. These latter still discuss more health topics than other kind of documents. This review confirms that the most discussed transport health issues are those described by Kjellstrom et al. (2003): air pollution, safety, active transport and noise (Figure 4). However, Kjellstrom et al. (2003) don't identify the EPI risk among the first factors driving the transport sector. Globally, the EPI risk is likely to be discussed in documents which treat a wide range of health topics. Indeed, the more health topics are addressed, the more the EPI risk will be addressed or mentioned (Table 8). While this affirmation can be logical and obvious, this review observes some documents to address complex and rarer health topics without mentioning the EPI risk. Visual pollution (Arup, 2014) or the link between working from home and the commuting trip number (Smargiassi et al. 2020) might be seen as less critical than the EPI risk. Although working from home can be linked to the EPI risk through a different exposure to air pollution. Conversely, emergency response is not widely addressed despite it concerns both transport management and health through, for example, the organization of bus lanes, pedestrian zones or tramway network schemes (Alexander, 2015). Overall, poor details are provided on the choice of health topics, particularly among grey literature. Some topics are directly linked to the main object of the research (e.g., documents addressing ageing people and transport discuss health accessibility). Six documents discuss an *'other'* health topic, different than healthcare accessibility, without addressing, mentioning (directly or indirectly) the EPI risk. For example, the link between spatial justice and health is addressed by three geography researchers in Ergler et al. 2020. Likewise, Ray Hammond, who discusses DNA and gene-editing (Allianz Partners, 2019), wrote in 1986 the book *The Modern Frankenstein: Fiction becomes fact*. A book in which he argues that the ultimate scientific goal is the control of human evolution (Hammond, 1986). Hence, the choice to prioritize an

*'other'* health topic over the EPI risk can be partly explained by authors' discipline, background or previous work. Among grey literature documents, understanding the choice of the discussed health topics remains hard to catch, owing to a poor communication on methodology or genesis of the document or study.

Among documents not addressing or mentioning the EPI risk, health is not left aside. While governments define policies and strategies, local institutions are in charge to decline those guidelines in practice. This explains the high occurrence of more specific health topics in documents produced by local entities. Thus, leading to a communication which is more adapted to daily and practice implications. 'Cleanliness' or 'comfort' constitute the most important indirect reference to the EPI risk, and translate passengers' expectations. It might be unlikely to see passengers clearly needing cleaner transports specifically to prevent epidemic or pandemic spread, particularly before the Covid-19 outbreak. Moreover, the notion of comfort reveals that people's consideration goes beyond cleanliness. But both cleanliness and comfort could be discussed (Castaldo et al. 2018). Do passengers expect a biological cleanliness? Or do they expect a visual, an aesthetic cleanliness? Privé (2016) reminds about car sharing that the experience is driven by a 'question of atmosphere'. It is easy to define cleanliness of transport as the absence of risk to be dirtied or contaminated by viruses or bacteria. However, the perception of cleanliness might differ from one to another (Castaldo et al. 2018).

In a similar way, the lack of EPI risk mention in local scenarios may signify cleanliness is not a priority and is deliberately concealed. Some cities may consider cleanliness doesn't need to be addressed in a future scenario, if they already reached satisfactory levels (e.g., Singapore famous for its overall cleanliness) (Straughan, 2019).

The range of health topics discussed remains finally context dependent. Documents addressing air transportation won't probably address active transport, while research studying bus networks would discuss this aspect owing to its link with inter-modal passenger transport. Furthermore, even the seven documents which aimed to specifically address health in transport provide poor discussion of the EPI risk (Table 9).

This lack of consideration is critical and reflects a worrying oversight since these documents address more health topics (4,14 on average) than documents discussing transport future through a wider lens. The case of the report

‘Health 2020: Transport and Health’ (WHO, 2015) is particularly disturbing as no mention of the EPI risk can be found. ‘Respiratory diseases’ are quickly mentioned but not respiratory infections, or infections in general. That, despite the World Health Organization regularly publishes documents, reports or procedures on pandemic preparedness, with dedicated webpages on, for example, Ebola or Avian and other zoonotic diseases (WHO, 2020a; 2020b). How can we expect a comprehensive inclusion of the EPI risk in documents, researches or policies if the health ‘guardians of the temple’ fail to spread their recommendations in their own publications?

**Table 9** Documents specifically discussing health

| Document               | Health focus            | EPI risk             | Health topics number |
|------------------------|-------------------------|----------------------|----------------------|
| ACOLA, 2014            | Transport public health |                      | 4                    |
| ILC-UK, 2015           | Elderly health          | Indirectly mentioned | 5                    |
| Shergold et al. 2015   | Elderly health          |                      | 4                    |
| Smargiassi et al. 2020 | Environmental health    |                      | 5                    |
| Stevenson et al. 2016  | Transport health issues | Mentioned            | 4                    |
| WHO, 2015              | General health          |                      | 4                    |
| Will et al. 2019       | General health          |                      | 3                    |

Alongside that, the EPI risk is however regularly acknowledged as a major disruptor, able to impact most aspects of life. Nevertheless, it remains mostly seen as a health issue, thus verifying the second hypothesis of this review. IATA (2018) and Peeters et al. (2019) identify the EPI risk as a consequence of climate change and environmental destruction, but not as a threat to the environment. For the purpose of this review, exploring how health was discussed in transport scenarios and guidance documents was the only way to assess how the EPI risk was considered. However, the aim of this paper was also to broaden the way of perceiving the EPI risk. Particularly to sketch the EPI risk’s environmental implications. The disruption of transport network, and specifically pandemic-related measures foster the management of transports under a modified capacity (Figure 9, Figure 10). However, the EPI risk can lead to the decrease of emissions owing to travel restrictions or lockdown measures (Arora et al. 2020; Zambrano-Monserrate et al. 2020). Similarly, the cancellation of cultural events, for example, might decrease the demand for public transport as well as pollution, with less GHGs emissions. Nevertheless, the EPI risk might also increase pollution through the use of cleaners, sanitizers, disposable masks or response equipment (e.g., signs,

posters) (Fadare and Okoffo, 2020; Livingston et al. 2020; Saadat et al. 2020).

Restrictions on stores opening may also strongly modify consumption patterns (Baker et al. 2020; Hall et al. 2020). The impacting production and delivery patterns as well. Consequently, it is likely to see important changes, for example, in Life Cycle Analysis (LCAs).



**Fig. 9** Seats restriction in a bus, Portland, Oregon, USA (Steve Morgan). Recopied under the GNU Free Documentation License



**Fig. 10** Restriction to 2 passengers maximum in an elevator which normal limit is about 13 people (1000 Kg). Co-working office ‘Le 22’, Castres, France

Until we can analyze the aftermath of the Covid-19 pandemic, few possibilities will be offered to correctly quantify each impact’s scope. In the context of population growth, density and human-wildlife proximity will increase the risk to see an infection scaling up to epidemic or pandemic. Thus increasing health and environmental impacts (Di Marco et al. 2020). Moreover, a new Covid-19-

equivalent pandemic peak would critically worsen the overall situation (Elliott, 2020; OECD, 2020).

Therefore, this review corroborates and reaffirms the environmental implications of the EPI risk, as a key component of sustainability, as described by Jones et al. (2008), Morse et al. (2012), Allen et al. (2017) and Di Marco et al. (2020).

From this disaster, the entire world is offered a chance to modify its mechanic. Therefore, it remains essential to include the EPI risk in all transport guidance documents, policies or future scenarios, not only as a health disruptor, but also as a global disruptor, paying a special attention to the environment. Sarkodie and Owusu (2020) already discussed the necessity to address the environment-health-economic nexus regarding the pandemic. I wish to go further by calling to consider both the EPI risk and environment in every predictive research. Research and transport sectors should adopt more holistic, inter- and trans-disciplinary approaches and increase interactions with all stakeholders (Graiss et al. 2003).

## 5 Limitations

In this review, some transport means are poorly represented. Few or no papers have been found addressing future scenarios for maritime passengers' transport or elevators. This latter is of a critical importance regarding the EPI risk as it offers a confined space, a control panel touched by all users and can be strongly impacted by distancing measures (e.g., 2 passengers only, despite a greater passenger capacity) (Figure 10). Especially since it is one of the first shared transport means (franceinfo, 2016), subject to promising improvements (counterweights can be used to generate energy), thus modifying LCAs. Moreover, the use of elevators may have other health impacts linked to active transport (discouraging the use of stairs) (Meyer et al. 2010; Yang et al., 2007). For example, in France, elevators represent 100 million trips/day (Fédération des Ascenseurs, 2020).

Goods transportation, clandestine migration or troop transportation, were beyond the scope of this review. Nonetheless, these aspects are also concerned by the EPI risk since these people also share roads or public spaces (e.g., highway service stations). This paper is also limited by the research only made in English and French. Other languages could provide further transport scenarios or guidance documents, particularly at the local scale. In addition, the Covid-19 and its impacts remain poorly known (e.g., will the observed changes in behaviours towards consumption, globalization or the environment last?).

Moreover, specific scenarios (e.g., only focused on energy, or technology) can possibly mention or address the EPI risk as a disruptor, even if it is not the core of their research.

Since data collection was done under lockdown measures or services and library closures, the research sample is limited to open-access documents and the literature which was accessible through the Bournemouth University subscriptions.

## 5 Conclusion

This review answered its initial question and concludes that the EPI risk was poorly addressed in public transport guidance documents and future scenarios, before the Covid-19 pandemic. This lack of consideration appears even more important in view of the large number of health topics discussed. Health topics which are sometimes complex and of a less critical importance regarding public health. However, this paper observes that the more health topics are addressed, the more the EPI risk is likely to be discussed. Likewise, global and national scale documents are likely to discuss the EPI risk. This paper also observes that the EPI risk is indirectly addressed as 'cleanliness' and 'comfort' needs in local studies. This study, then notices the absence in transport future scenarios of transport means such as elevators or maritime passenger transports. Hence, further studies should be done to correctly include these means. In the EPI risk context, the notion of public transports should be expanded to encompass freight workers, troops and clandestine migration, in order to catch a comprehensive range of public space users who are likely to spread a virus.

A second aim of this review was to trigger a new vision of the EPI risk, particularly about the environmental impacts it can lead to. Indeed, the EPI risk is only addressed through the prism of health. Environmental impacts are poorly discussed in transport scenarios and guidance documents, despite the EPI risk, when mentioned, is often acknowledged as a major and critical disruptor for the environment. Probably the Covid-19 pandemic will impulse a greater consideration of the EPI risk in many fields, including research and public transport. Nevertheless, it is essential to strengthen bonds between all fields, to make inter- and trans-disciplinarity the new rule. The circular, blue or green economies are so many tools which can help us to adopt holistic approaches and to bring the planet towards a healthier world.

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