Miami-Dade Board of County Commissioners
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Review of Studies on Passenger Seat Size on Commercial Airplanes

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Yinka Majekodunmi, CPA
Commission Auditor
Office of the Commission Auditor (OCA)
111 N.W. First Street, Suite 1030
Miami, FL 33128
(305) 375-2524

Research Team

Jacques Pierre-Louis, MBA, BCC Associate Auditor
Luis Carrazana, CPA, BCC Associate Auditor

The Office of the Commission Auditor, Miami-Dade Board of County Commissioners

The Office of the Commission Auditor (OCA) was established in September 2002 by Ordinance 03-2 to provide support and professional analysis of the policy, service, budgetary, and operational issues before the Miami-Dade Board of County Commissioners. The Commission Auditor's duties include reporting to the Board of County Commissioners (BCC) on the fiscal operations of County departments, as well as whether or not the fiscal and legislative policy directions of the Commission are being efficiently and effectively implemented.

This report, prepared in collaboration with the Miami-Dade County departments and external contributors as subject matter experts, is substantially less detailed in scope than an audit in accordance with the Generally Accepted Auditing Standards (GAAS). The Office of the Commission Auditor plans and performs the review to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our objectives; accordingly, OCA does not express an opinion on the data gathered by the subject matter expert.

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I. Purpose

This report abridges the results of the Office of the Commission Auditor (OCA)'s search for the availability of relevant studies conducted on passengers' accommodations in commercial flights as it relates to seat pitch, seat size, and legroom; and how these affect passengers' comfort, health, and safety, and more specifically, on whether some of those studies support a specific size seat for passengers. To achieve its objective, OCA reviewed numerous available studies for the following:

1. The extent to which the adjustment of seat pitch, seat size, and legroom impacts passengers' accommodation.
2. The extent to which the adjustment of seat pitch, seat size, and legroom leads to increased health or safety concerns for passengers.

II. Background

Shrinking aircraft accommodations in commercial airlines has been part of the national conversation for decades[1]. The main issue being discussed stems from customer perception that the airline industry has been reducing seat pitch, seat size and legroom in order to add more seats and passenger capacity[2], which has conveyed the impression over time that airlines have lowered passengers' comfort and may have contributed to health and safety concerns during flights.

Changes to passengers' accommodation started after the deregulation of the airline industry by Congress in 1978. In that year, Congress, in an effort to remove the federal government control over such areas as fares, routes and market entry of new airlines, passed the Airline Deregulation Legislation Act. The Act introduced a free market in the commercial airline industry and led to an increase in the number of flights, a decrease in fares, an increase in the number of passengers and miles flown, and a consolidation of carriers[3]. It also gave airlines more considerable latitude in the way they manage cabin space in the pursuit of profitability. As a result, in their efforts to make the most efficient ergonomic use of cabin space, some airlines have reduced seat pitch **(*the distance between one point of a seat to the same point in the seat in front of it*)** from 34/35 inches to 30/31 inches, and as low as 28 inches on some domestic flights[4] depending on the type of airline and the fare class purchased, which has prompted concerns of comfort, health, and safety for passengers from consumer advocates and others.

At the core of the issue of passengers' seating accommodation, is the topic of passenger seating configurations, which involves considerations for seat width, padding, reclining, pitch, legroom and aisle width as they relate to anthropometry − *The scientific study of the measurements and*

[1] Article accessed https://www.usatoday.com/story/travel/columnist/mcgee/2018/11/15/airline-seat-size-faa/2003043002/
[2] Article https://www.bloomberg.com/news/articles/2019-07-25/this-airline-plans-to-break-a-record-cramming-flyers-into-jets
[3] Article https://www.govtrack.us/congress/bills/95/s2493/summary
[4] Article https://www.bloomberg.com/news/articles/2019-07-25/this-airline-plans-to-break-a-record-cramming-flyers-into-jets

proportions of the human body. Depending on how the airlines adjust these factors in seat design, passengers might end up with less or more space for comfort.

Congress took on the airlines practice of reduced aircraft accommodation a few years ago; and consequently, in its Federal Aviation Authority (FAA) Reauthorization Act of 2018, it mandated the FAA to, among other things, issue within one year, a rule that sets minimum standards for airline seat pitch, seat size and legroom ***(the distance from the middle point of a seat cushion to the furthest point on the back of the seat in front of it)***[5] while simultaneously ordering a study of plane evacuations, including the effect seat size and legroom have on emergency evacuations. Figure 1 below illustrates seat pitch and legroom:

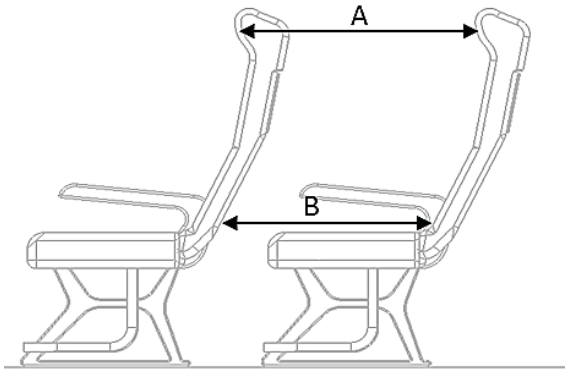

Figure 1: Seat pitch (A) and legroom (B)

III. Summary

We reviewed various documents, including five studies about our main objective, and our review indicates the following:

a) The researchers' views diverge in their discussions on passenger seating accommodation, but regardless of their perspective, their analysis of passengers' comfort or discomfort include considerations for anthropometric and ergonomic factors. For example, researchers in this study: ***The effects of seat width, load factor, and passenger demographics on airline passenger accommodation,*** understand seating accommodation from a spatial point of view, and their understanding also includes load factor (an indicator of how planes are occupied). They considered three different conditions of accommodation: strict, margin, and compression[6]. All these conditions involve anthropometric and ergonomic factors as they pertain to how to best accommodate a passenger's body in a seat.

[5] Article www.timesunion.com/travel/article/Spirit-Airlines-new-seat-pitch-14426008.php

[6]Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson (2019). ***The Effect of Seat Width, Load Factor, and Passenger Demographics on Airline Passenger Accommodation***. Ergonomics 62:2, 330-341, p. 335.

b) Specific observations and conclusions from the researchers can serve as guides for the airlines in addressing passenger seating accommodation. Below are some of the most pertinent ones:

i. Increasing load factor (percentage of seats filled) leads to decreased accommodation levels[7].

ii. Beginning with a seat pitch of 28 inches, the feeling of being restricted decreases toward a minimum level at around 40 inches (in other words, at a seat pitch of 40 inches, the feeling of being restricted is reduced to its lowest level). A similar result was obtained for the feeling of being stressed[8].

iii. The seat pitch for maximum well-being ranges from 34 to 42 inches for a corresponding legroom range of 32 – 40 inches[9].

iv. The value of hip breadth seated appears to be increasing for multiple populations at a rate of about 2.3 percent per decade. Consequently, a seat width of 15.91 inches that could accommodate 95 percent of females in 1986 would require a corresponding width of 17.1 inches, a 7.4 percent increase as of the year 2014[10].

v. A width of 19.7 inches between the armrests would be necessary to accommodate every nationality's seated hip breadth based on the analysis of a global sample data[11].

vi. The ideal passenger seat pitch is around 30-31 inches[12]. A majority of passengers support government seat pitch regulation, and 65 percent of them feel that airlines should be required to increase the seat pitch on their aircraft if the regulated minimum was higher than their current seating configuration[13].

c) Some researchers acknowledge that a reduction in passengers' accommodation can pose serious health and safety risks for passengers[14], [15]. However, these concerns were not found to be the central focus of any of the studies. Thus, the impacts of reduction in passengers' accommodation in terms of health and safety have not been measured.

IV. Passenger Accommodation: Seat pitch, Seat size, and Legroom

To better understand seat pitch, seat size, and legroom in the context of passengers' accommodation in the reviewed studies, it is imperative to understand how passengers' accommodation is viewed by the researchers.

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[7] Ibid, p. 337.
[8] Ibid. p. 4942.
[9] Ibid. p. 4942.
[10] Faculty of Industrial Design Engineering (2017, June). ***Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present and future***. Applied Ergonomics, 65, 1-24, p. 9. http://resolver.tudelft.nl/uuid:c95c6482-e10e-4a1a-8b4c-bf70009855eb
[11] Ibid. p. 13.
[12], Scott R. Winter (2019). ***Government Seat Pitch Regulation of Commercial Airlines: A Multi-Study of Consumer Perceptions***, Collegiate Aviation Review International, 37:2, 1-15, p. 11. https://ojs.library.okstate.edu/osu/index.php/CARI/article/view/7891/7295
[13] Ibid p. 3.
[14] Ibid p. 3.
[15] Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson (2019). ***The Effect of Seat Width, Load Factor, and Passenger Demographics on Airline Passenger Accommodation***. Ergonomics 62:2, 330-341, p. 332-333.

In four of the five studies reviewed, we distinguished four different approaches to passenger accommodation. Authors Elizabeth L. Miller, Samuel M. Lapp and Matthew B. Parkinson focused strictly on hip breath in individual accommodation in their 2019 study: ***The effects of seat width, load factor, and passenger demographics on airline passenger accommodation***, passengers accommodation is viewed as part of the overall accommodation of the planeload which is defined simply as the ratio of accommodated passengers to the total number of passengers[16].

Individual accommodation from the authors perspective is understood from a spatial point of view and can be assessed in a number of ways. Thus, they considered three different conditions for passengers' accommodation: strict, margin, and compression[17].

In the simplest sense, an individual can be considered accommodated on hip breadth if their hip breadth is less than the seat width. This strict accommodation measure neglects factors such as clothing and posture[18].

Margin has to do with adding additional space to the hip breadth width for strict accommodation for clothing and movement allowance. The researchers did that by using design guidelines for seated environments from The Human Factors and Ergonomics Society[19].

For accommodation with compression, a passenger is considered to be accommodated if his hip breadth minus a compression margin is smaller than the seat width. This value was arbitrarily determined by the researchers in their study and was subtracted from the hip breadth of each individual. For many low-Body Mass Index passengers, this amount of tissue compression is impossible. However, it is likely that these passengers' hip breadths are already narrower than the seat[20]. Additionally, the researchers also discussed what they call Contextual Accommodation. They suggest that passengers in a window or aisle seats enjoy greater accommodation than others because they can raise the interior armrests and thereby expand their seat width[21].

For Florian Kremser, Fabian Guenzkofer, Claudia Sedlmeier, Olaf Sabbah, and Klaus Bengler, authors of the 2012 study: ***Aircraft seating comfort: the influence of seat pitch on passengers' well-being***, accommodation involves considerations for comfort as well as discomfort. For them, comfort is not simply the absence of discomfort, and both can occur at the same time. Citing previous studies, they maintain that comfort is mainly associated with pain and biomechanical factors. It has also been identified as associated with relaxation, luxury, and well-being[22]. The researchers explain the following inputs as factors influencing comfort and discomfort: history, state of mind, visual input, environmental factors (e.g., smell, noise, temperature, and humidity),

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[16] Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson (2019). ***The Effect of Seat Width, Load Factor, and Passenger Demographics on Airline Passenger Accommodation***. Ergonomics 62:2, 330-341, p. 335.
[17] Ibid pp. 335-336.
[18] Ibid p. 336.
[19] Ibid p. 336.
[20] Ibid p. 335.
[21] Ibid p. 336.
[22] Florian Kremser, Fabian Guenzkofer, Claudia Sedlemeier, Olaf Sabbah, and Klaus Bengler (2012). ***Aircraft Seating Comfort: The Influence of Seat Pitch on Passengers' Well-being.*** Institute of Ergonomics 41, 4936- 4942, p. 4936. https ://content.iospress.com/download/work/wor0789?id=work%2Fwor0789

pressure distribution, posture, and movement. Thus, the overall well-being of a passenger is influenced by physiological and psychological factors[23].

J.F.M. Molenbroek, T. J. Albin and P. Vink, authors of ***Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present and future***, a 2017 study, addressed passengers' accommodation in their study by focusing on the concept of the seating space volume, which is defined by the width, length and seated height of passengers[24]. The desired dimensions of the seating space volume are those that concurrently accommodate a given proportion of all passengers on all three dimensions[25]. Though three dimensions are needed for accommodation in seating space volume considerations, the authors only discussed width and depth in detail. They were also very mindful of the value of personal space in anthropometric accommodation.

Suzanne Hiemstra-van Mastrigta, Liesbeth Groenesteijna, Peter Vinkb, and Lottie F. M. Kuijt-Eversa, authors of ***Predicting passenger seat comfort and discomfort on the basis of human, context and seat characteristics: a literature review,*** another 2017 study, are among those researchers who understand accommodation based on considerations for comfort and discomfort. They espouse the view that passenger seats should allow people to feel fit after traveling for a few hours without experiencing discomfort. Therefore, accommodating passengers requires developing an understanding of comfort and discomfort. Citing previous studies, they propound that comfort and discomfort are two independent factors associated with different underlying factors[26].

Discomfort is associated with feelings of pain, soreness, numbness, and stiffness, and is caused by physical constraints in the design. Comfort, on the other hand, is associated with feelings of relaxation and well-being, and can be influenced by, for example, the aesthetic impression of a product or environment. Thus, reducing the level of experienced discomfort will not necessarily increase the level of comfort, but in order to accomplish a high level of comfort, the level of discomfort needs to be low[27].

Further illumining the issue of accommodation is the author's explanation of the relationship between human, seat, and context characteristics and the perception of comfort and discomfort. They argue that the relationship can be explained by three mediating variables: posture, pressure, and movement. For example, body posture is not only determined by a passenger's anthropometry, but also by the seat characteristics (e.g., reclined backrest angle) and context (the performed activity, such as reading or working on a laptop)[28].

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[23] Ibid p. 4936.
[24] Faculty of Industrial Design Engineering (2017, June). ***Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present and future***. Applied Ergonomics, 1-24, p. 3. http://resolver.tudelft.nl/uuid:c95c6482-e10e-4a1a-8b4c-bf70009855eb
[25] Ibid p. 3.
[26] Suzanne Hiemstra-van Mastrigt (2017). ***Predicting Passenger Seat Comfort and Discomfort on the Basis of Human, Context, and Seat Characteristics: a literature review***. Ergonomics 60:7, 889-911, p. 890.
[27] Ibid p. 890.
[28] Suzanne Hiemstra-van Mastrigt (2017). ***Predicting Passenger Seat Comfort and Discomfort on the Basis of Human, Context, and Seat Characteristics: a literature review***. Ergonomics 60:7, 889-911, p. 891.

V. Results of Studies: Seat pitch, Seat size, and Legroom

OCA reviewed the selected studies below to determine to what extent passengers are inconvenienced when factors such as seat pitch, seat size, and legroom are adjusted to various levels.

Study 1. ***The effects of seat width, load factor, and passenger demographics on airline passenger accommodation***.

The authors (Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson) analyzed accommodation in the 2019 study in the context of the following parameters: seat dimensions, proportion of seats on the plane that are filled, the ratio among passengers of men to women and the conditions for accommodation, researchers observed that as load factor (a ratio expressed as the number of occupied seats divided by the number of available seats in an airplane) increases, there are fewer open seats to extend the effective width of a passenger's seat. This results in decreased accommodation levels. As seat width decreases, the effect of load factor becomes more noticeable. Also, reviewing previous works for this study, the researchers highlighted the result of a survey in which passengers identified the airplane seat as the most important context feature for comfort, with legroom being the second most[29].

Study 2. ***Aircraft seating comfort: the influence of seat pitch on passengers' well-being.***

In this 2012 study which involved survey and simulation and in which comfort and discomfort were associated with psychological as well physiological factors, the authors (Florian Kremsera, Fabian Guenzkofera, Claudia Sedlmeiera, Olaf Sabbahb, and Klaus Benglera) asked the participants to rate their subjective feelings/impressions for different seat pitches within a range of 28 inches to 43 inches, with each seat pitch being matched by a corresponding legroom[30]. The results indicated that seat pitch influences subjects' perception of sitting posture and spatial perception.

Regarding its influence on subjects 'perception, researchers found that beginning at a seat pitch of 28 inches, the ability to adopt a comfortable posture and to change ones' posture increases. At a seat pitch of 36 inches, a saturation of the dependent variables is reached[31]. The results show that the easiness of adopting a comfortable sitting posture and the easiness of changing one's posture is significantly influenced by the seat pitch.

Beginning with a seat pitch of 28 inches, the feeling of being restricted begins to decrease to a minimum level at around 40 inches. Also, the feeling of being stressed out because of the available space reaches its minimum at around 40 inches[32]. The feeling of sitting in front of a wall continues

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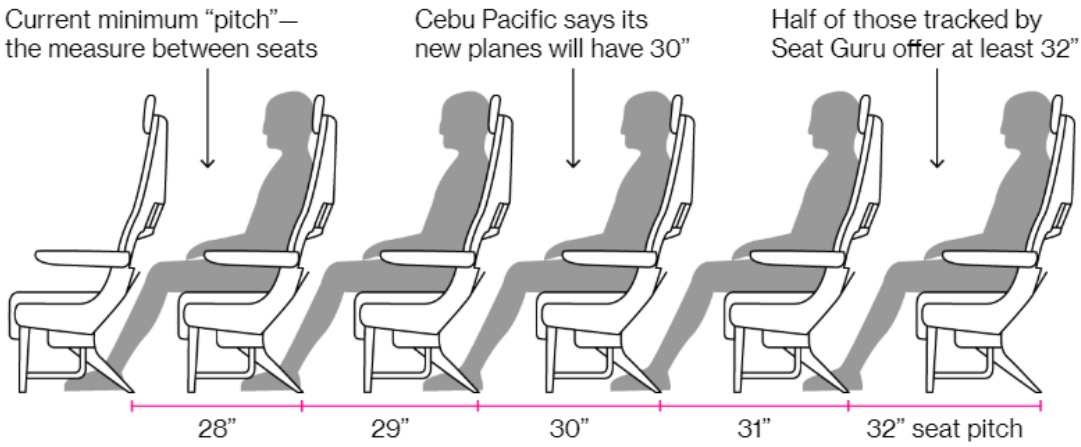
[29] Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson (2019). ***The Effect of Seat Width, Load Factor, and Passenger Demographics on Airline Passenger Accommodation***. Ergonomics 62:2, 330-341, p 337.

[30] Florian Kremser, Fabian Guenzkofer, Claudia Sedlemeier, Olaf Sabbah and Klaus Bengler (2012). ***Aircraft Seating Comfort: The Influence of Seat Pitch on Passengers' Well-being.*** Institute of Ergonomics 41, 4936-4942, p. 4938. https://content.iospress.com/download/work/wor0789?id=work%2Fwor0789

[31] Ibid. p. 4939.

[32] Ibid p. 4939.

to improve as the seat pitch increases. The feeling of being lost is more or less constant from 28 to 36 inches, with improvement in passenger feeling beginning after 36 inches [33]. Figure 2 below illustrates the various differences in seat pitch:[34]



Source: Seat Guru

Comparing the results of posture and spatial perception with the results of overall well-being, the seat pitch for maximum well-being ranges from 34 inches to 42 inches. (legroom of 32 to 40 inches), depending on the passenger's anthropometry[35]. According to this study, legroom and space for passengers are mainly influenced by seat pitch.

Study 3. ***Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present and future.***

Researchers (J.F.M. Molenbroek, T. J. Albin and P. Vink) in this 2017 study made the following observation regarding hip breath, a value used to calculate seat width:

It is important to note that the value of seated hip breadth appears to be increasing for multiple populations, as is indicated by the student data gathered at Technology University and the US military data, and that appears to be increasing at a rate of about 2.3 percent per decade. To illustrate this, a seat width of 15.91 inches would have accommodated 95 percent of females in 1986, whereas the corresponding width in 2014 would have to be 17.1 inches to accomplish the same accommodation, a 7.4 percent increase in width. Seat width was defined in that study as the distance between the armrests[36].

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[33] Ibid p. 4939.

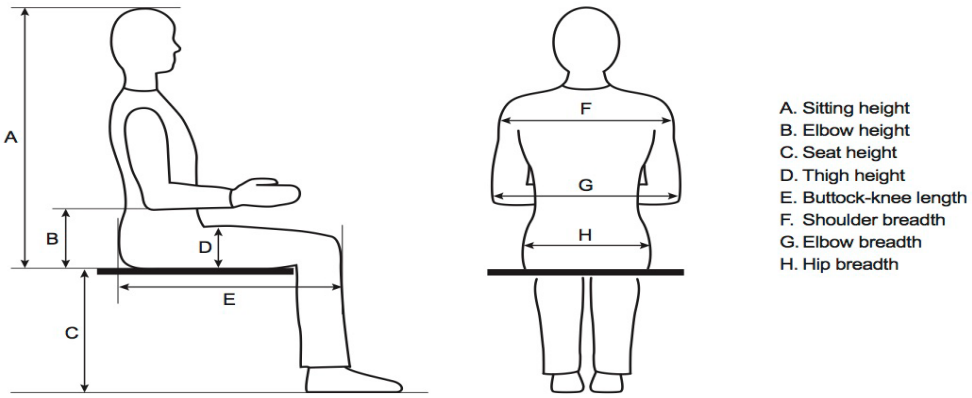
[34] https://www.bloomberg.com/news/articles/2019-07-25/this-airline-plans-to-break-a-record-cramming-flyers-into-jets Bloomberg: ***Think Legroom on Planes Is Bad Now? It's Going to Get Worse***.

[35] Ibid p. 4942.

[36] Faculty of Industrial Design Engineering (2017, June). ***Thirty years of anthropometric changes relevant to the width and depth of transportation seating spaces, present, and future***. Applied Ergonomics, 65, 1-24, p. 9. http://resolver.tudelft.nl/uuid:c95c6482-e10e-4a1a-8b4c-bf70009855eb

The above observation and others led the researchers to conclude that seating designers must take these increases in widths into consideration when designing seating intended to be used for decades into the future[37]. They also observed, based on a sample global anthropometric data analyzed for the same study, that current seating space designs may not adequately accommodate a significant proportion of the intended users at present, a situation that will not improve if the trend towards increasing passenger widths continues. Their analysis of the data sample also suggests that a width of 19.7 inches between the armrests would be necessary to accommodate every nationality's seated hip breath based on the 95th percentile of values of reported in the data sample[38].

Figure 3 below illustrates a schematic drawing of some anthropometric dimensions relevant to the design of transportation seating systems:[39]



<u>Study 4</u>. ***Government seat pitch regulation of commercial airlines: a multi-study of consumer perceptions.***

Participants in this 2019 study were asked by the researcher (Scott R. Winter) to express their sentiments regarding the need for government regulation of seat pitch. They were presented with a statement defining seat pitch in which it was said that the pitch in economy class is 29 to 32 inches[40].

The results of the study indicated that participants ideal seal pitch were around 30-31 inches[41]. Researchers did not clarify whether participants would experience discomfort in seat pitches below 29 inches. The study also revealed that not only a majority of the participants favored government

[37] Ibid. p. 13.
[38] Ibid. p. 13.
[39] Ibid. p. 21.
[40] Scott R. Winter (2019). ***Government Seat Pitch Regulation of Commercial Airlines: A Multi-Study of Consumer Perceptions, Collegiate Aviation Review Internationa***l, 37:2, 1-15, p. 8. https://ojs.library.okstate.edu/osu/index.php/CARI/article/view/7891/7295
[41] Scott R. Winter (2019). ***Government Seat Pitch Regulation of Commercial Airlines: A Multi-Study of Consumer Perceptions, Collegiate Aviation Review Internationa***l, 37:2, 1-15, p.11. https://ojs.library.okstate.edu/osu/index.php/CARI/article/view/7891/7295

regulation, but that 65 percent of participants felt airlines should be required to increase the seat pitch on their aircraft if the regulated minimum was higher than their current seating configuration. That study did not include any analysis for seat size[42].

Study 5. ***Predicting passenger seat comfort and discomfort on the basis of human, context, and seat characteristics: a literature review.***

In pursuing their objective of building a model that could predict passenger comfort and discomfort, researchers (Suzanne Hiemstra-van Mastrigt, Liesbeth Groenesteijn, Peter Vink, and Lottie F. M. Kuijt-Evers) discussed in this 2017 study, among other issues, the effects of personal space on comfort and discomfort.

According to the researchers, personal space is a broad concept that includes variables such as legroom, seat pitch, and cabin environment, which affect the perception of comfort and discomfort. Other researchers cited discovered that seat pitch for maximum well-being ranges from 34 to 42 inches (corresponding legroom 32–40 inches), depending on the passenger's anthropometry[43]. After this maximum threshold, the level of subjective well-being decreases. The optimal seat pitch is influenced by the passenger's buttock–knee-length, and the sense of subjective well-being is influenced by the passenger's eye height. The 'ease of adopting a comfortable sitting posture' and the 'ease of changing posture,' as well as the 'feeling of being restricted,' the 'feeling of sitting in front of a wall' and the 'feeling of being lost,' were significantly influenced by seat pitch. It was also found that the width per seat at seated eye level provided the best correlation with passenger preference for an airplane, which indicates that personal space is more important than total space[44].

The researcher aimed to study the relationships between the human, seat, and context variables in order to predict passenger comfort and discomfort[45]. They found that correlations do exist between anthropometric variables and interface pressure variables, and that this relationship is affected by body posture. But they fell short of being able to build their model because the strength of one of the correlations was not clear, and also because they believed more variables than the ones studied in their review had to be *taken* into account[46].

VI. Passengers' Health, and Safety

Since the airline's practice of reducing passengers' accommodation has raised concerns about health and safety for passengers, we reviewed the selected studies to determine to what extent the adjustment to seat pitch and seat size correlates to health and safety issues for passengers. Of the five studies that OCA reviewed, the two studies below and the added newspaper article discussed health and safety as part of their overall narrative.

[42] Ibid. p. 13.
[43] Suzanne Hiemstra-van Mastrigt (2017). ***Predicting Passenger Seat Comfort and Discomfort on the Basis of Human, Context, and Seat Characteristics: a literature review***. Ergonomics 60:7, 889-911, p. 909.
[44] Ibid. p. 909.
[45] Ibid. p. 906.
[46] Ibid. p. 906.

In study 4, ***Government Seat Pitch Regulation of Commercial Airlines: A Multi-Study of Consumer Perceptions***, discussing the FAA regulations which dictate that in the event of an emergency, commercial aircraft must be evacuated within 90 seconds or less, researchers relayed that critics suggest that the trials for which aircraft manufacturers conduct these tests fail to include all members of the population, such as the elderly. Also, it was conveyed that a recent study evaluated the elderly's ability to ingress and egress from commercial aircraft seats and found that they do take significantly more time than younger members of the population, and support themselves more through touching armrests and backrests[47].

In relation to the issue of passengers' health, citing previous researchers, the author asserted that medical issues, such as deep vein thrombosis, pulmonary embolism, and restricted mobility, could all be detrimental issues of sitting in a cramped area for an extended period. However, these health concerns are also related to the length of the flight and resulting time spent in these limited spaces[48]. Research conducted on the most favorable seat pitch for passenger overall well-being found that the optimal seat pitch was between 34-40 inches[49].

In study 1, ***The effects of seat width, load factor, and passenger demographics on airline passenger accommodation***, researchers reviewed a 2014 study in which they identified the health implications that small seats can impose on passengers. Sitting in an airplane seat that is too small may cause passengers to experience extra pressure and contact stresses on their bodies. Small seats may also hinder their ability to move. Sitting immobile for a long period of time can cause discomfort and pain from static loading on the body and increase the possibility of thromboembolism, according to the study[50].

It was also concluded in another reviewed study that reductions in seat pitch and seat width pose safety and health issues. Constrained spaces that restrict mobility can be a factor in passengers developing conditions like deep vein thrombosis. Additionally, the reduced space can also decrease the ability of passengers to quickly and safely disembark the plane in the event of an emergency[51].

In a newspaper article titled: ***Aviation expert warns shrinking legroom could be dangerous***, Professor Jan Davies, the chair of the International Board of Research into Aircraft Crash Events in Canada, expressing his concerns about reduced seat pitch, told an aviation safety conference in 2017 that cramped seats were making it difficult for passengers to adopt the brace position in a crash or emergency landing. He added "If your seat pitch is less than 30 inches, you will not be able to properly brace if you are of average height as well as if you are a tall person or a larger person because there's just not much space[52]."

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[47] Scott R. Winter (2019). ***Government Seat Pitch Regulation of Commercial Airlines: A Multi-Study of Consumer Perceptions, Collegiate Aviation Review Internation***al, 37: 2, 1-15, p. 3. https://ojs.library.okstate.edu/osu/index.php/CARI/article/view/7891/7295

[48] Ibid. p. 3.

[49] Ibid. p. 3.

[50] Elizabeth L. Miller, Samuel M. Lapp & Matthew B. Parkinson (2019). ***The Effect of Seat Width, Load Factor, and Passenger Demographics on Airline Passenger Accommodation***. Ergonomics 62:2, 330-341, p. 332.

[51] Ibid. p. 333.

[52] Article https://www.news.com.au/travel/travel-advice/health-safety/aviation-expert-warns-shrinking-leg-room-could-be-dangerous/news-story/a03c056430ae3000653f78df68a8b4e3

Passengers are instructed to adopt the brace position to prepare for a crash or an emergency landing on land or water. It usually requires passengers to keep their feet firmly on the floor with knees together, while holding their head against the surface it is most likely to strike on impact, such as the seat in front[53].

VII. Conclusion

Mitigating between passengers' comfort, health, and safety with the need to carry the maximum number of passengers to ensure profitability will require the airline industry to find the optimal balance. Although some passengers can afford to pay for the more spacious seats that fulfill their comfort, safety, and health needs, that does not preclude the need for a minimum standard for seat pitch, seat size, and legroom since more passengers fly low-class carriers due to the affordability.

Although the studies reviewed did not finalize any experiment into a specific level of seat pitch, seat size, and legroom that leads to increased health and safety, this concern cannot be dismissed entirely since at least one expert warns that a shrinking seat pitch below 30 inches is dangerous[54].

[53] Ibid.
[54] Ibid.