Jurnal Biologi Tropis

Original Research Paper

Factors Associated with Nasal Mucociliary Clearance Time in Elderly Nursing Home Residents

Wan Andre Nugraha Baros[1], Delfitri Munir[1*], Devira Zahara[1], Siti Nursiah[1], Farhat[1], Taufik Ashar[2]

[1]Department of Otorhinolaryngology – Head and Neck, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia;

[2]Public Health Faculty, Universitas Sumatera Utara, Medan, Indonesia;

Article History
Received : May 16th, 2026
Revised : May 27th, 2026
Accepted : June 16th, 2026

*Corresponding Author:
Delfitri Munir, Department of Ear, Nose & Throat, Head & Neck, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia;
Email:
delfitri_munir@yahoo.com

Abstract: The mucociliary transport system is an essential defense mechanism of the nasal cavity that helps remove pathogens, allergens, and particles. Impairment of this system may prolong mucociliary clearance time (MCT) and increase susceptibility to infection. Aging and systemic conditions may influence mucociliary function. This study aimed to evaluate the association between age, gender, diabetes mellitus, hypertension, and smoking history with nasal mucociliary clearance time in elderly individuals. An analytical cross-sectional study was conducted in a nursing home in Medan over three months. A total of 40 elderly participants were included. Nasal mucociliary clearance time was measured using the saccharin test. Data were analyzed using the Chi-square test. The mean mucociliary clearance time was 16.45 minutes. A significant association was found between age and MCT, as well as between gender and MCT, with males showing better clearance time than females. No significant associations were observed between MCT and diabetes mellitus, hypertension, or smoking history. Age and gender are significantly associated with nasal mucociliary clearance time in the elderly, while diabetes mellitus, hypertension, and smoking history are not. These findings suggest that physiological aging and gender-related differences may influence nasal defense mechanisms, highlighting the importance of considering these factors in respiratory health assessment in the elderly.
.

Keywords: Elderly; Factor; Mucociliary transport.

Introduction

The mucociliary transport system is a key defense mechanism of the upper respiratory tract that maintains nasal homeostasis by facilitating the clearance of inhaled pathogens, allergens, and particulate matter. Impairment of this system leads to prolonged nasal mucociliary clearance time (MCT), allowing accumulation and penetration of harmful agents into the respiratory epithelium, thereby increasing susceptibility to infection and respiratory diseases (Wackym & Snow, 2017).

Aging is associated with progressive structural and functional changes in the respiratory epithelium, including reduced ciliary activity and impaired mucosal defense mechanisms. In addition, elderly individuals often exhibit a chronic low-grade inflammatory state, known as “inflammaging,” characterized by increased levels of pro-inflammatory cytokines such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α), along with dysregulated immune responses. These changes contribute to reduced mucociliary efficiency and increased susceptibility to respiratory infections (Franceschi et al., 2018; Akbar & Gilroy, 2020).

Elderly populations residing in nursing homes are particularly vulnerable due to advanced age, multiple comorbidities, and continuous exposure to institutional

This article is licensed under a Creative Commons Attribution 4.0 International License.

© 2026 The Author(s). This article is open access

environments. However, data regarding nasal mucociliary clearance function among elderly individuals in nursing homes in Indonesia, including Medan, remain limited. Therefore, understanding factors associated with impaired MCT in this population is important for early identification of individuals at risk of respiratory dysfunction and infection.

Several methods can be used to evaluate mucociliary function, including assessment of mucociliary clearance transport (MCT), ciliary ultrastructure, ciliary beat frequency, and mucus properties. At the tissue level, mucociliary transport is regulated by the coordinated interaction between ciliated epithelial cells and mucus layers (Broaddus et al., 2021). The mucociliary clearance system consists of two fluid layers (the periciliary sol layer and the mucus gel layer) and motile cilia on the epithelial surface. Inhaled particles are trapped in the mucus layer, while coordinated ciliary movement within the periciliary layer facilitates their transport toward the nasopharynx for clearance. Effective mucociliary clearance depends on both ciliary function and the optimal balance of mucus and periciliary fluid (Koeppen & BA, 2017).

Previous studies have demonstrated that mucociliary transport time increases with age. Yadav (2011) reported progressively prolonged nasal mucociliary transport times across age groups, ranging from 7.34–7.36 minutes in individuals aged 41–50 years to 14.48–15.38 minutes in those aged 61–70 years. This indicates age-related decline in ciliary function, which may increase susceptibility to respiratory infections and is also observed in conditions such as Kartagener syndrome, cystic fibrosis, asthma, bronchiectasis, chronic bronchitis, and sinusitis (Singh & Ranga, 2011). Similarly, de Oliveira-Maul et al. (2013) found prolonged saccharin transit times in 54 patients aged >60 years compared with only 19 cases in those aged <40 years.

Mucociliary transport time (MCT) can be assessed using several techniques, including indigo carmine dye testing, gamma scintigraphy, and the saccharin test (Batmaz & Tokgöz, 2020). The saccharin test involves placing saccharin particles on the anterior end of the inferior turbinate and measuring the time until the subject perceives a sweet taste when the particle reaches the pharynx. MCT values measured by saccharin or other methods show a wide normal range, typically 1–20 minutes, with an average of approximately 12–15 minutes (Darmawan, 2010). The saccharin test is widely used due to its simplicity, low cost, non-invasive nature, and good reproducibility, with results comparable to those obtained using radio-labeled particle techniques (Yasa, 2008).

Previous studies have shown that nasal mucociliary clearance time may be influenced by aging and various systemic conditions; however, findings regarding the effects of gender, diabetes mellitus, hypertension, and smoking history remain inconsistent across different populations. Moreover, limited studies have specifically evaluated these factors simultaneously in elderly individuals living in nursing home settings, particularly in Indonesia where local evidence is still scarce. This gap in the literature highlights the need for population-specific data to better understand determinants of mucociliary function in institutionalized elderly subjects. Therefore, this study aims to determine the effect of age, gender, diabetes mellitus, hypertension disease, and smoking history on nasal mucociliary transport time in elderly residents of a nursing home in Medan City.

.

Materials and Methods

Research methods

This study is an analytical observational study with a cross-sectional design conducted in a nursing home in Medan City for 3 months. The total duration of data collection was approximately three months. A cross-sectional design was chosen because it allows the assessment of the relationship between exposure variables (age, gender, diabetes mellitus, hypertension, and smoking history) and the outcome variable (nasal mucociliary transport time) at a single point in time.

The study population consisted of all elderly residents in the nursing home who were willing to participate. Sampling was performed using a purposive sampling technique, in which subjects were selected based on predefined inclusion criteria and researcher judgment. This method was considered appropriate to ensure that

DOI: http://doi.org/10.29303/jbt.v26i2.12407

participants met specific clinical conditions required for accurate mucociliary assessment. However, purposive sampling may introduce selection bias and limit the generalizability of the findings, particularly because the sample was drawn from a single institution.

The independent variables in this study were age, gender, diabetes mellitus, hypertension, and smoking history, while the dependent variable was nasal mucociliary transport time. The inclusion criteria were as follows:

1. Age >60 years (Permenkes, 2015)
2. No upper respiratory tract infections (e.g., common cold, rhinosinusitis) or lower respiratory diseases (e.g., COPD, pulmonary tuberculosis) based on anamnesis
3. No history of rhinoplasty
4. No nasal polyps
5. No inferior turbinate hypertrophy
6. No history of allergic rhinitis
7. Not using nasal drops

Nasal mucociliary clearance time was defined as the duration required for saccharin particles to be transported from the anterior end of the inferior turbinate (approximately 1 mm posterior to the anterior border) to the nasopharynx, indicated by the perception of a sweet taste.

Data analysis

The data collected in this study were primary data obtained from direct measurement of nasal mucociliary transport time in elderly residents of a nursing home in Medan City. The primary data included age, gender, diabetes mellitus, hypertension, and smoking history obtained through structured interviews with participants or caregivers, as well as nasal mucociliary transport time measured using the saccharin test performed by the researchers.

Nasal mucociliary clearance time (MCT) was categorized into normal and prolonged based on established reference values, with MCT considered prolonged when exceeding the normal range reported in previous studies (approximately >15 minutes). This categorization was used to allow categorical statistical analysis.

Data were presented in tabular form and analyzed using the Chi-square test with a 95% confidence level to assess the association between independent variables and MCT categories. The Chi-square test was applied under the assumptions that observations were independent, variables were categorical, expected frequencies in each cell were ≥5 in at least 80% of cells, and no cell had an expected count of zero.

In addition, logistic regression analysis may be applied as a multivariate approach to determine the independent effect of each variable on prolonged MCT while controlling for potential confounding factors such as age, gender, and comorbidities. This method is appropriate because the outcome variable (normal vs prolonged MCT) is dichotomous.

Result and Discussion

Characteristics of study sample

Most of the 40 participants were male (57.5%) and aged over 70 years (60%), with a mean age of 73.95 ± 7.48 years. The majority did not have diabetes mellitus (77.5%) or hypertension (57.5%). Smoking history was present in 40% of participants, and half of these were heavy smokers. Overall, the sample consisted mainly of elderly individuals with relatively low comorbidities but a notable proportion of smokers. The demographic characteristics of the research subjects are shown in table 1.

Tabel 1. Charactheristics of Study Sample

Demographics Charactheristics	N = 40
Gender n %	
• Male	23 (57,5)
• Female	17 (42,5)
Age n %	
• > 70 years old	24 (60)
• ≤ 70 years old	16 (40)
• Mean (SD), years	73,95 (7,48)
	73,5 (61-89)

DOI: http://doi.org/10.29303/jbt.v26i2.12407

Demographics Characteristics	N = 40
• Median (min-max), years	
DM, n %	
• Yes	9 (22,5)
• No	31 (77,5)
Hypertension, n %	
• Yes	17 (42,5)
• No	23 (57,5)
Smoking history, n %	
• Yes	16 (40)
• No	24 (60)
Smoking degree, n %	
• Severe	8 (50)
• Moderate	4 (25)
• Low	4 (25)

Nasal Mucociliary Time within subjects

Table 2 shows the results of the examination of the time of nasal mucociliary transportation. The average nasal mucociliary transportation time of all subjects in this study was 16.45 minutes with the fastest time being 9.54 minutes and the longest being 29.25 minutes. A total of 23 subjects (57.5%) showed a prolonged nasal mucociliary clearance time (> 15 minutes).

Table 2. Nasal Mucociliary Time within subjects

Nasal Mucociliary clearance time	N = 40
Mean (SD), minutes	16,45 (4,42)
Median (min-max), minutes	15,34 (9,54-29,25)
> 15 minutes	23 (57,5)
≤ 15 minutes	17 (42,5)

Corellation between demographics characteristics and mucocilliary clearance time

Table 3 shows the results of a bivariate analysis of the relationship between sex, age, smoking habits, diabetes mellitus, hypertension diseases and nasal mucociliary clearance time. There was a significant association between gender and mucociliary clearance time (p = 0.015), with males showing a higher proportion of prolonged clearance time (73.9%) compared to females (35.3%), and males had about twice the risk of prolonged MCT (RP = 2.094; 95% CI: 1.053–4.167). Age was also significantly associated with MCT (p = 0.037), where participants aged >70 years had a higher proportion of prolonged clearance time (70.8%) compared to those ≤70 years (37.5%), with an increased risk (RP = 1.889; 95% CI: 0.954–3.738).

Diabetes mellitus, hypertension, smoking history, and smoking degree showed no statistically significant association with mucociliary clearance time (p > 0.05), although smoking history showed a trend toward higher risk (RP = 1.636; 95% CI: 0.974–2.749). Overall, prolonged mucociliary clearance time was significantly associated with older age and male gender, while comorbidities and smoking did not show significant effects in this study.

Table 3. Corellation between demographics charactheristics and mucocilliary clearance time

Demographics Charactheristics	Mucociliary clearance time		P	RP (95% CI)
	Lengthen	Normal		
Gender n %				2,094 (1,053-4,167)
• Male	17 (73,9)	6 (26,1)		
• Female	6 (35,3)	11 (64,7)	0,015[a]	
Age n %	17 (70,8)	7 (29,2)		1,889 (0,954-3,738)

Demographics Charactheristics	Mucociliary clearance time		P	RP (95% CI)
	Lengthen	Normal		
• > 70 years old	6 (37,5)	10 (62,5)	0,037[a]	
• ≤ 70 years old				
DM, n %	5 (55,6)	4 (44,4)		0,957
• Yes	18 (58,1)	13 (41,9)	1,000[b]	(0,496-1,845)
• No				
Hypertension, n %	9 (52,9)	8 (47,1)		
• Yes	14 (60,9)	9 (39,1)		0,870
• No			0,616[a]	(0,499-1,515)
Smoking history, n %	12 (75)	4 (25)		
• Yes	11 (45,8)	13 (54,2)		1,636
• No			0,068[a]	(0,974-2,749)
Smoking degree, n %				
• Severe and moderate	8 (66,70)	4 (33,3)		
• Low and non smokers	15 (53,6)	13 (46,4)	0,443[a]	1,244 (0,734-2,110)

Multivariate analysis of factors associated with mucocilliary transport time

The multivariate analysis was performed to determine which independent variable has the most dominant influence in predicting the timing of nasal mucociliary disorders. In addition, to obtain a formula for calculating the probability of nasal mucociliary transportation time from significant independent variables from the results of multivariate analysis. The type of multivariate analysis used is multiple logistic regression because the dependent variable in this study is categorical. The variables included in the multivariate analysis were independent variables that had a p value <0.25 from the results of bivariate analysis. The independent variables that met the requirements were gender, age, and smoking habit.

Table 4. Multivariate analysis of factors associated with mucocilliary transport time

Variable	B	P	Exp (B)	95% CI	
				Lower	Upper
Selection I					
Gender	2,121	0,018	8,338	1,449	47,989
Age	1,953	0,030	7,050	1,205	41,237
Smoking	0,915	0,246	2,497	0,533	11,705
Constant	-2,372	0,017	0,093		
Selection II					
Gender	2,224	0,011	9,241	1,669	51,163
Age	2,029	0,021	7,608	1,359	42,597
Constant	-2,088	0,021			

Discussion

Summary of Findings

This study included 40 subjects from a nursing home in Medan. The majority of participants were male, aged >70 years, and non-smokers. Among smokers, severe smoking exposure was more frequently observed compared to moderate and mild categories. The mean nasal mucociliary clearance time was 16.45 minutes, with most participants (23 subjects) showing prolonged mucociliary clearance time (>15 minutes), indicating reduced mucociliary function in this population.

Interpretation of Findings

The high proportion of prolonged mucociliary clearance time suggests a general decline in nasal mucociliary function among elderly individuals in institutional settings. This may reflect age-related structural and physiological changes in the respiratory

DOI: http://doi.org/10.29303/jbt.v26i2.12407

epithelium, leading to reduced ciliary activity and impaired clearance of inhaled particles.

Comparison with Previous Studies

A significant association was found between age and mucociliary clearance time ($p < 0.05$). This finding is consistent with de Oliveira – Maul et al., (2013), who reported that mucociliary clearance time increases with age, with older individuals showing significantly slower transport times compared to younger subjects. Age-related decline in mucociliary function may be associated with anatomical, physiological, and biochemical changes during aging, which affect respiratory defense mechanisms (Paul et al., 2013).

A significant association was also observed between gender and mucociliary clearance time ($p < 0.05$). This is consistent with Bennett et al. (2013), who found better mucociliary clearance in females compared to males. Bennett et al. explained that anatomical differences, particularly shorter proximal bronchial length in females, contribute to faster particulate clearance (Bennett et al., 2013). Similar findings were also reported by Armengot et al. (1993) and Gerrard et al. (1986), who demonstrated that females generally have more efficient mucociliary transport. This difference may also be influenced by hormonal factors, including the presence of progesterone receptors in the respiratory tract, as well as anatomical differences in airway length.

In contrast, this study found no significant association between diabetes mellitus or hypertension and mucociliary clearance time. This finding is not consistent with Olivera-Maul et al. (2013), who reported that both conditions may impair mucociliary transport. They suggested that antihypertensive drugs such as beta-blockers may reduce ciliary beat frequency, while diuretics may affect mucus hydration and periciliary layer function. Gurung and Aggarwal also reported that diabetic neuropathy and metabolic disturbances may contribute to reduced mucociliary function. Additionally, changes in mucus structure and composition, including glycoproteins, proteoglycans, lipids, and DNA content, may alter mucociliary transport efficiency. Reduced ATPase activity and altered ionic regulation may further contribute to delayed mucociliary clearance in diabetic patients.

Similarly, no significant relationship was found between smoking and mucociliary clearance time in this study. This finding is inconsistent with Xavier et al. (2014), who reported that moderate and heavy smokers had significantly prolonged saccharin test times compared to light smokers and non-smokers ($p < 0.0001$). Xavier et al. also demonstrated a positive correlation between cigarette consumption and delayed mucociliary transport, indicating that smoking contributes to impaired mucociliary function (Xavier et al., 2014).

Clinical Implications

The findings of this study suggest that age and gender are important determinants of nasal mucociliary clearance function in elderly individuals. Prolonged mucociliary clearance time may increase susceptibility to respiratory infections, particularly in nursing home populations. Therefore, assessment of mucociliary function may be useful for early identification of individuals at higher risk of respiratory complications.

Study Limitations

This study has several limitations. The sample size was relatively small and limited to a single nursing home in Medan, which may affect generalizability. The cross-sectional design limits causal inference between risk factors and mucociliary clearance time. In addition, potential confounding factors such as medication use, environmental exposure, nutritional status, and physical activity were not fully controlled.

Conclusion

The present study demonstrated a significant association between gender and nasal mucociliary transport time, with males exhibiting longer transport times than females. Age was also found to be significantly associated with nasal mucociliary transport time, as older subjects tended to have prolonged mucociliary clearance times, indicating a decline in mucociliary function with advancing age. Although no significant relationship was observed between smoking history and nasal mucociliary transport time, a trend toward slower mucociliary transport was noted among elderly subjects with light, moderate, and heavy smoking exposure. Furthermore, no significant associations were identified between a history of diabetes mellitus or hypertension and nasal mucociliary transport time. Overall, gender and age appear to be important factors influencing nasal mucociliary clearance, whereas smoking history, diabetes mellitus, and hypertension did not demonstrate statistically significant effects in the study population.

Acknowledgement

The authors would like to thank Nany, MD for participation and helps in this studies.

Reference

Akbar, A. N., & Gilroy, D. W. (2020). Aging immunity may exacerbate COVID-19. *Science, 369*(6501), 256–257. https://doi.org/10.1126/science.abb0762

Armengot, M., Barona, R., Garín, L., & Basterra, J. (1993). The influence of age, sex and circadian rhythms on the nasal mucosal in the mucociliary clearance. *Anales Otorrinolaringologicos Ibero-Americanos*, *20*(6), 581–588.

Batmaz, S. B., & Tokgöz, S. A. (2020). Relationship between nasal mucociliary clearance and disease severity in children with allergic rhinitis: A comparative cross-sectional study. *Allergologia et Immunopathologia*, *48*(2), 137–141.

Bennett, W. D., Laube, B. L., Corcoran, T., Zeman, K., Sharpless, G., Thomas, K., Wu, J., Mogayzel Jr, P. J., Pilewski, J., & Donaldson, S. (2013). Multisite comparison of mucociliary and cough clearance measures using standardized methods. *Journal of Aerosol Medicine and Pulmonary Drug Delivery*, *26*(3), 157–164.

Broaddus, V. C., Ernst, J. D., King Jr, T. E., Lazarus, S. C., Sarmiento, K. F., Schnapp, L. M., Stapleton, R. D., & Gotway, M. B. (2021). *Murray & Nadel's textbook of respiratory medicine e-book*. Elsevier Health Sciences.

Brocklehurst, J. C., Fillit, H. M., & Tallis, R. C. (1998). *Brocklehurst's textbook of geriatric medicine and gerontology*. Churchill Livingstone.

de Oliveira-Maul, J. P., de Carvalho, H. B., Goto, D. M., Maia, R. M., Flo, C., Barnabe, V., Franco, D. R., Benabou, S., Perracini, M. R., & Jacob-Filho, W. (2013). Aging, diabetes, and hypertension are associated with decreased nasal mucociliary clearance. *Chest*, *143*(4), 1091–1097.

Fahy, J. V., & Dickey, B. F. (2010). Airway mucus function and dysfunction. *New England Journal of Medicine, 363*(23), 2233–2247. https://doi.org/10.1056/NEJMra0910061

Feldman, C., & Anderson, R. (2013). Mucociliary clearance and respiratory infections. *Current Opinion in Pulmonary Medicine, 19*(3), 229–235.

Franceschi, C., Garagnani, P., Parini, P., Giuliani, C., & Santoro, A. (2018). Inflammaging: A new immune–metabolic viewpoint for age-related diseases. *Nature Reviews Endocrinology, 14*(10), 576–590. https://doi.org/10.1038/s41574-018-0059-4

Gerrard, C. S., Gerrity, T. R., & Yeates, D. B. (1986). The relationships of aerosol deposition, lung size, and the rate of mucociliary clearance. *Archives of Environmental Health: An International Journal*, *41*(1), 11–15.

Gurung, A., & Aggarwal, B. B. (2013). Diabetes and airway mucociliary dysfunction: Mechanisms and implications. *Respiratory Medicine, 107*(5), 673–680.

Ho, J. C. M., Chan, K. N., Hu, W. H., et al. (2001). Effect of aging on nasal mucociliary clearance. *Clinical Science, 101*(5), 567–571.

Koeppen, B. M., & BA, S. (2017). Berne and levy physiology e-book: Elsevier health sciences. *United States: Mosby*.

Paul, P., Johnson, P., Ramaswamy, P., Ramadoss, S., Geetha, B., & Subhashini,

A. S. (2013). The effect of ageing on nasal mucociliary clearance in women: A pilot study. *International Scholarly Research Notices*, *2013*(1), 598589.

Rutland, J., & Cole, P. J. (1980). Non-invasive sampling of nasal ciliary function. *The Lancet, 316*(8206), 122–125.

Singh, J., & Ranga, R. K. (2011). Effects of aging on nasal mucociliary clearance. *Clinical Rhinology*, *4*(1), 1–3.

Stanley, P. J., & Wilson, R. (2015). Effects of smoking on mucociliary clearance. *Thorax, 70*(5), 467–474.

Stanley, P., & MacWilliam, L. (2012). Assessment of nasal mucociliary clearance: The saccharin test revisited. *Clinical Otolaryngology, 37*(3), 201–206. https://doi.org/10.1111/coa.12024

Wackym, P. A., & Snow, J. B. (2017). *Ballenger's otorhinolaryngology: Head and neck surgery*. PMPH USA.

World Health Organization. (2015). *World report on ageing and health*. WHO Press. https://www.who.int/publications/i/item/9789241565042

Xavier, R. F., Ramos, D., Ito, J. T., Rodrigues, F. M. M., Bertolini, G. N., Macchione, M., De Toledo, A. C., & Ramos, E. M. C. (2014). Effects of cigarette smoking intensity on the mucociliary clearance of active smokers. *Respiration*, *86*(6), 479–485.

Yasa, Y. F. (2008). *Perbedaan Waktu Transportasi Mukosiliar Hidung pada Penderita Rinosinusitis Maksila Kronis dengan Kavum Nasi Normal*. Universitas Sumatera Utara