Inhalation Adherence Among Older Males with Chronic Obstructive Pulmonary Disease: A Structural Equation Model Applying the Theory of Planned Behavior

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Objectives: Theoretical frameworks such as the theory of planned behavior (TPB) may provide a basis to study psychological factors associated with inhalation adherence among individuals with chronic obstructive pulmonary disease (COPD). The present study was designed to assess the predictability of TPB constructs for adequate adherence to inhalation therapy among this population. **Methods:** Using convenience sampling, 374 Taiwanese males with COPD (mean age: 72.69 years [SD±9.53] completed the Intention of Inhaled Medication Adherence Scale (which is based on TPB constructs), and the Test of Adherence to Inhalers Questionnaire. Structural equation modeling (SEM) was used to assess direct/indirect associations and likely mediating mechanisms. **Results:** The SEM model indicated a good fit and demonstrated the direct effects of subjective norms (β=0.254, p=0.003) and attitude (β=0.186, p=0.018) on adherence intention. There was also an indirect association between subjective norms and adherence through behavioral intention (β=0.039; p=0.046). **Conclusions:** The TPB appears to be a suitable theoretical framework to assess inhalation adherence among individuals with COPD. Further research is warranted using the theory among individuals with different sociodemographic variables affected by COPD as well as those with other respiratory conditions.

Keywords: Chronic Obstructive Pulmonary Disease, Theory of Planned Behavior, Inhalation Therapy, Treatment Adherence, Behavior Change.

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Chronic obstructive pulmonary disease (COPD) is a prevalent but preventable and manageable disease.[1] It results in continuous respiratory symptoms and airflow difficulty due to abnormalities in the airway or alveoli of the lungs that is usually caused by considerable exposure to harmful particles or gases.[2] Overall, cigarette smoking and air pollution are the most important

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risk factors for developing COPD.[1] It is usually a progressive disease that may be accompanied by other comorbidities such as arterial hypertension, lung failure, and dyspnea that may lead to a significant reduction in health-related quality of life.[3] COPD is responsible for nearly three million deaths annually, and is ranked among the ten leading causes of mortality worldwide according to World Health Organization (WHO).[4,5] Based on published studies, its prevalence varies from 10%-20% in the USA but is lower in Asia-Pacific regions (approximately 6%).[6-8] In Taiwan (where the present study was conducted), studies have shown that approximately one in 10 individuals may suffer from the disease, and it was the seventh leading cause of mortality among the Taiwanese population in 2015.[9,10]

Overall, COPD is more common among middle-aged and older-aged individuals (particularly among those who have been exposed to various risk factors), and its prevalence increases with age.[11] There is also increased morbidity and mortality among the elderly than among younger people.[12] Nearly one-fifth of all annual hospitalizations among older people aged 75 years or higher in the United States are attributed to COPD, and after heart disease, it is recognized as the most common cause of disability adjusted life-years in that country.[1,11,13] Physiological changes due to aging such as reduced lung elasticity, decreased expiratory flow, and decreased pulmonary volume, as well as increased stiffness of the chest cage make the elderly more prone to COPD and its related complications.[14] Moreover, diagnosis of COPD among older people is often delayed due to factors such as manifestation of non-specific symptoms, low awareness of the disease among the clinicians (and the older population), and lower use of diagnostic measures including spirometry at primary healthcare for this population.[15] Cognitive changes, physical limitations, and decreased social support among elderly individuals may also exacerbate receiving appropriate care and eventually increase the negative outcomes related to COPD among older people.[16,17]

Generally, COPD is not a curable disease, and available medications or treatments may help with symptom mitigation and alleviate its complications.[3] However, inhalation medicines are an important part of pharmacological treatment, and adherence to long-term inhalation therapy is key to effective disease management.[18] There are various definitions for adherence in the literature. However, according to Delamater[19], it refers to some active, voluntary, and participatory patient involvement in a mutually agreeable course of behavior to generate a therapeutic outcome. As the WHO has noted, any poor adherence to the treatment of non-communicable and chronic diseases should be considered a serious barrier that impedes achieving any significant health improvement and may considerably increase the costs of treatment for the health system and patients.[20] Therefore, adherence to inhalation, which refers to the degree to which an individual with COPD may use an appropriate technique of inhalation therapy with accurate medication dose, has a significant role in disease management and preventing life-threatening complications.[21] The evidence shows individuals with COPD who adequately adhere to inhaled therapy are better able to control the disease's symptoms and have fewer exacerbations or hospitalizations (as well as a better quality of life and physical activity tolerance) than individuals with non-/poor adherence.[22]

Different factors may influence adherence. For example, several studies have shown that adherence can be affected by demographic factors (e.g., age, education level, and income), clinical variables (e.g., length of morbidity, comorbidities, and number of medications), and psychological factors (e.g., degree of satisfaction regarding the treatment, mood conditions, and having negative attitude and beliefs on effectiveness of treatment).[23-25] One study showed that when individuals perceive that the disease is likely to affect their daily routines and that non-adherence is likely to have severe health consequences, the likelihood of treatment adherence increases.[26] Moreover, other beliefs and better communication with healthcare providers influence adherence.[27,28] Other psychological variables such as self-efficacy, perceived social support, and knowledge of appropriate use of inhalers may also contribute to inhalation adherence.[29-31]

Because almost half of individuals with chronic disorders do not usually adhere to their therapeutic recommendations,[20] especially among individuals with chronic respiratory conditions, the adherence rate ranges widely (from 10% to 78%).[22,32] Therefore, applying robust theoretical frameworks to understand factors influencing the adherence and planning of appropriate interventions to overcome likely barriers is recommended. Moreover, recognizing the models/theories that may successfully predict adherence are helpful in informing any programs targeting

adherence improvement among individuals with chronic diseases such as COPD. Indeed, utilizing appropriate behavior change theory may not only improve individuals' compliance with pulmonary rehabilitation programs but it may also facilitate such individuals in changing their health-related behaviors and self-management capacities.

Despite the many useful theories/models applicable to such situations, only a limited number of them are currently used by researchers to guide their studies.[33] The theory of planned behavior (TPB) is one of the most widely used theoretical frameworks that is promising in predicting different health behaviors, including treatment adherence.[34] According to this theory, behavioral intention is the immediate predictor of behavior and is determined by three other factors: attitude, subjective norms, and perceived behavioral control. Attitude refers to the individual's appraisal of the likability or usefulness of the behavior; subjective norms refer to perceived social pressure or norms from important others. Moreover, subjective norms are individual beliefs regarding how others from the person's close social context may think about doing or not doing a given behavior. These are influenced by personal beliefs about the outcomes of a particular behavior as well as the degree to which a person wants to act based on the important others' desires. However, these differ from motives of authority to accept treatment or legitimacy of people's health behaviors.[35,36] Moreover, perceived behavioral control refers to an individual's perception of their ability to conduct the behavior and its controllability.[37]

The TPB assumes a causal chain that links a system of beliefs to predict the precursor of actual behavior (i.e., intention) and provides a systematic approach to clarify the essential components of a personal decision to conduct a particular behavior. Consequently, the TPB, has been increasingly applied as a context to design and evaluate behavior change programs and their effectiveness.[38] The constructs of the TPB have all been theoretically tested and validated in different social psychology and public health domains, and has demonstrated promising results.[39] Consequently, the TPB has been recognized as a well-established social psychological theory in understanding how socio-psychological variables may contribute to willingness toward performing various behaviors.[40]

Several systematic reviews have shown that the TPB may predict significant proportions of variance regarding the intention and behavior, indicating the theory's feasibility for different health-related behaviors.[41-43] Moreover, different measures that have been developed based on the TPB to assess health-related behaviors have reported acceptable psychometric properties.[44-46] For example, the Cronbach's alpha as an index of internal consistency for these measures has ranged from 0.78-0.92 indicating reliability of the measures across different populations.[43,47] The applicability of the TPB to indicate adherence behaviors has also been documented in several studies.[48,49] Chevance et al. used the TPB among individuals with COPD and sought the effect of its variables on sedentary behaviors and exercise. They found that an intervention based on the TPB may increase perceived behavioral control and intention toward exercise alongside a better attitude toward rehabilitation programs.[50] In another study, Ricke et al. found that the TPB effectively improved adherence to recommendations provided by physical therapists among individuals with COPD.[51] Wang et al. used the TPB to develop a psychometrically robust scale (Intention of Inhaled Medication Adherence Scale) to understand how TPB constructs may affect inhaled medication adherence among individuals with COPD.[52] The scale was found to be useful in assessing likely factors associated with inhalation adherence among this population. Because the scale showed acceptable validity and reliability, the present study assessed its feasibility using structural equation modeling by applying an actual behavioral component (i.e., inhalation adherence).

The objectives of the present study were to investigate further the associations between TPB constructs and the target behavior (inhalation adherence) and to identify the potential pathways and mediation effects of TPB constructs in predicting adherence. Moreover, the present study only focused on male participants to control the potential gender effects on study findings. More specifically, prior evidence shows that male and female may have different levels of adherence, and factors associated with their inhaler adherence might be different[21].

METHODS

Participants and Data Collection

The data for the present study were collected using convenience sampling between November 2021 and May 2023 by a professional respiratory therapist and a trained research assistant at the Chest Outpatient

Department of a district hospital in Chiayi, Taiwan. The participants were living in suburban and rural areas of Chiayi and were of relatively low-level socioeconomic status. Moreover, all the participants were Han Chinese and culturally influenced by Confucianism and collectivism. Rigorous inclusion criteria were applied, encompassing participants who met the following conditions: (i) having a daily prescription of at least one inhaler, (ii) having a diagnosis of COPD based on a post-bronchodilator FEV1/FVC ratio of less than 70%, utilizing ICD-10 codes J44-J49,[53] (iii) being aged 40 years or older, and (iv) being a male.

Participants were excluded from the study if they (i) declined to participate, (ii) exhibited cognitive impairments discerned by the research assistant or respiratory therapist, and/or (iii) failed to provide written informed consent. Ethical approval (202101706B0C601) was obtained from the Institutional Review Board of Chang Gung Medical Foundation, in accordance with the ethical guidelines of the Declaration of Helsinki to ensure the protection of participants' well-being and rights.

Of the 403 patients with COPD approached that met the eligibility criteria, 378 participants participated (94% response rate). Four participants were subsequently excluded from the analysis due to incomplete or invalid survey responses. The meticulous handling of missing data ensured the integrity and reliability of the subsequent analyses and findings.

Main Outcome Measures

The TPB structural model was employed to assess adherence to inhalation medication among patients diagnosed with COPD, and the Intention of Inhaled Medication Adherence Scale (IMAS) was used as the assessment tool. The IMAS is a 19-item instrument that evaluates adherence to inhaled medication among COPD patients within the framework of the TPB.[54] The scale comprises four sections representing different elements of the TPB model: (i) attitude (nine items), (ii) subjective norms (two items), (iii) perceived behavioral control (five items), and (iv) inhalation intention (three items). The items are responded to on a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The internal consistencies of the TPB factors, as measured by Cronbach's α, were high in the Chinese version of the IMAS. The α values were: attitude (α=0.93), subjective norms (α=0.81), perceived behavioral control (α=0.95), and inhalation intention (α=0.89).[54]

Detailed information regarding the four elements used in the IMAS is described below:

- *Attitude toward inhalation adherence:* This section assesses an individual's perceptions of the importance, experience, and evaluation of daily inhalation therapy for disease control. An example item is: *"I believe that using inhalers daily can improve respiratory symptoms (e.g., dyspnea, cough)"*.[52] Moreover, these items had excellent internal consistency in the present sample: α=0.93.
- *Subjective norms toward inhalation adherence:* This section assesses the influence of society on an individual's adherence to their daily medication regimen. An example item is: *"I use my inhalers daily with the encouragement of respiratory therapists and educators"*.[52] Moreover, these items had very good internal consistency in the present sample: α=0.82.
- *Perceived behavioral control toward inhalation adherence:* This section assesses the confidence level of individuals with COPD regarding their ability to adhere to their medication regimen consistently and correctly every day. An example item is: *"I can use my inhalers every day without help from others"*.[52] Moreover, these items had excellent internal consistency in the present sample: α=0.96.
- *Inhalation intention toward inhalation adherence:* This section assesses the individual's intention to use inhalers as prescribed. An example item is: *"It is okay to use my inhalers only once; even physicians ask me to do it twice a day"* (reversed item, so a higher score indicates lower intention).[52] Moreover, these items had very good internal consistency in the present sample: α=0.81.

Inhalation Adherence

The Test of Adherence to Inhalers Questionnaire (TAIQ) was used to evaluate adherence to inhaler use. The TAIQ comprises 12 items divided into the patient and healthcare professional domains. The patient domain includes the first ten items, rated on a 5-point Likert scale ranging from 1 (*always*) to 5 (*never*). The healthcare professional domain comprises the last two items. These items are presented as a checklist and rated on a scale from 1 to 2. The TAIQ assesses adherence levels using a 10-item version (i.e., the patient domain of TAI).

It categorizes adherence as poor (total score ≤ 45), intermediate (total score between 46 and 49), and good (total score=50).[55] A modified 12-item version assesses different types of non-adherence: sporadic, deliberate, and ignorant.[55] The Chinese version of the TAIQ has shown good internal consistency with a Cronbach's alpha coefficient of 0.843.[56] Moreover, these items had very good internal consistency in the present sample: α=0.82.

Statistical Analysis

The present study employed both IBM SPSS Statistics and the R *lavaan* package for statistical analyses. SPSS was used to conduct descriptive analysis, which involved examining key statistics such as means, standard deviations, skewness, and kurtosis for demographic variables, including age, gender, cigarette smoking history, family support, education level, and severity grouping of COPD. Additionally, Pearson correlation coefficients were calculated using SPSS to explore the associations between the constructs of the TPB model and inhalation adherence. A significance level of $p<0.05$ was used to determine statistical significance.

R software with *lavaan* package was used for structural equation modeling (SEM) to examine relationships between variables and confirmatory factor analysis (CFA) to ensure the construct validity of the measures. SEM helps evaluate how well a model fits the data and tests potential causal links. The present study used SEM to assess the TPB model's fit using various indices (i.e., χ^2, comparative fit index [CFI], Tucker-Lewis index [TLI], root mean square error of approximation [RMSEA], and standardized root mean square residual [SRMR]).[57] CFA adopts the same aforementioned fit indices to evaluate if the measures used in the present sample were valid. Both SEM and CFA were conducted using the diagonally weighted least squares (DWLS) estimator, which is effective for models with non-normal data.[57] The model fit was evaluated based on various criteria, including a nonsignificant χ^2, CFI greater than 0.9, TLI greater than 0.9, RMSEA less than 0.08, and SRMR less than 0.08.[57]

These criteria were employed to determine whether the proposed model adequately represented the data.[58] Once the model demonstrated a good fit, path analysis was performed to understand potential causal relationships and the model's predictive ability. Moreover, Sobel test was used to assess the mediation effects within the proposed SEM and investigate the indirect associations between the constructs

RESULTS

Characteristics of Participants

The mean age of the all-male participants (n=374) was 72.59 years (SD=9.53). Over half of the participants lived with their caregivers (n=264; 70.6%) and had successfully quit smoking (n=239; 63.9%). Their education status was relatively low: more than half of the participants did not complete junior high school education (n=225; 60.5%). The average duration of COPD diagnosis was 4.20 years (SD=2.56), and the severity of COPD indicated a lower risk profile, with most participants classified into groups A and B (n=344; 92.0%), indicating most participants had mild to moderate COPD. Table 1 summarizes the demographics and health characteristics of the participants.

Table 1
Patient Demographics (N=374)

		n (%)
Age (in years)[a]		72.69 (9.53)[a]
Sex	Male	374 (100%)
Smoking history	Non smoker	36 (9.6%)
	Active smoker	99 (26.5%)
	Ex-smoker	239 (63.9%)
Family support	Solitary	110 (29.4%)
	Caregiver	264 (70.6%)
Education	Uneducated	60 (16.1%)
	Elementary school	165 (44.4%)
	Junior high school	63 (16.9%)
	High school	80 (21.5%)
	College or above	4 (1.1%)
COPD group	A	257 (68.7%)
	B	87 (23.3%)
	E	30 (8.0%)
COPD duration (in years)		4.20 (2.56)[a]
Inhaler operating technique	No critical error	336 (89.8%)
	≥1 critical error	38 (10.2%)

Notes:
[a] Reported mean (SD)
Abbreviations: COPD, chronic obstructive pulmonary disease.

Correlation Matrix and CFA Findings

The correlation analysis showed significantly positive associations between TPB constructs (Table 2). Moreover, the CFA findings showed good data-model fit, indicating the measures used in the present study were valid in the present sample. More specifically, CFI=0.999, TLI=0.998, RMSEA=0.010, SRMR=0.050. Moreover, χ^2 test was not significant (χ^2=138; *df*=129; p=0.28) with a low ratio between χ^2 and degrees of freedom (χ^2/df=1.07).

Table 2
Correlation Matrix of Purpose Model

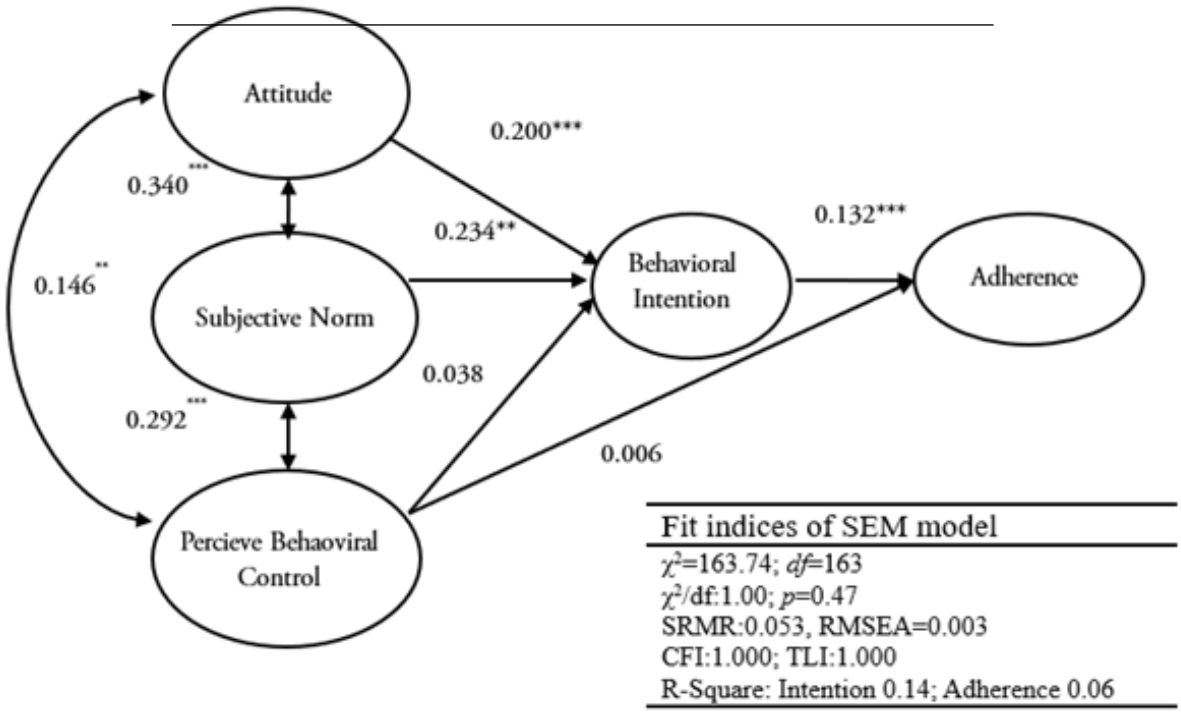
Constructs	1	2	3	4	5
1 Attitude					
2 Subjective Norm	0.321***				
3 Perceived Behavioral Control	0.130*	0.259***			
4 Intention	0.278***	0.274***	0.130*		
5 Adherence	0.064	0.078	0.013	0.102*	

Note.
p<0.05* p<0.01** p<0.001***

Findings from the Proposed Model

The fit indices for the proposed SEM model indicated excellent values (χ^2/df: 1.00, p-value: 0.47, SRMR: 0.053, RMSEA: 0.003, CFI: 1.000, TLI: 1.000). Path analysis showed subjective norms had the strongest direct effect on inhalation intention (β=0.234, p=0.001), followed by attitude (β=0.200, p<0.001). Mediation analysis indicated subjective norms showed a significantly indirect association with inhalation adherence through inhalation intention (β=0.038; p=0.010).

Figure 1
Path Map of Propose Model of TPB for Medication Adherence



Pathway Analysis for Purpose Model			
	Standardized Coefficient	*p*-value	
AT->IT	0.200	<0.001	***
SN->IT	0.234	0.001	**
PBC->IT	0.038	0.141	
PBC->Adherence	0.006	0.827	
IT->Adherence	0.132	<0.001	***
Mediation Effect			
	Standardized Coefficient	***p*-value**	
AT-> IT-> Adherence	0.030	0.001	**
SN->IT->Adherence	0.038	0.010	*
PBC->IT->Adherence	0.005	0.163	

p<0.05* p<0.01** p<0.001***
AT=Attitude; SN=Subjective norm; PBC=Perceived behavioral control; IT=Intention
χ^2: Chi-square; *df*: Degree of freedom; TLI: Tucker-Lewis index
SRMR: standardized root mean square residual; CFI: comparative fit index
RMSEA: root-mean-square error of approximation

DISCUSSION

The present study was conducted to examine how a popular theory of behavioral change (i.e., the theory of planned behavior [TPB]) may predict inhalation adherence among individuals with COPD, and the direct and indirect associations between TPB constructs and adherence behavior. The findings showed that the TPB appears to be an appropriate theory to explain how psychological concepts such as attitude, subjective norms, perceived behavioral control, and intention in association together may predict adherence to inhalation therapy among individuals with COPD, and as proposed by the model the intention would be a significant predictor of the behavior. In addition, the findings indicated that the association between constructs such as subjective norms and attitude were stronger than other correlations, and the subjective norms may directly or indirectly be more influential than others in forming any behavioral intention and adherence toward the inhalation therapy.

The TPB has been used in several studies to predict treatment adherence. Lin et al. examined the role of the TPB in medication adherence among individuals with epilepsy.[59] Similar to the present study, they used SEM for this purpose and found that the TPB constructs explained more than 50% of the variance of medication adherence, which is comparable to the present study's findings, and that the TPB was relevant in predicting adherence behavior. In another study, Yang et al. used the TPB to identify predictors of home-based exercise adherence for cardiac rehabilitation.[60] They used a self-report survey to assess adherence but used some proxy scales to assess some concepts related to TPB. For example, they used the Perceived Social Support Scale as a proxy for subjective norms and the Multidimensional Self-Efficacy for Exercise Scale as a proxy for perceived behavioral control. Although they found both of these proxies were significant predictors of exercise adherence for rehabilitation, developing a scale based on specific TPB constructs is likely to produce more accurate results than those found by Yang et al. because social support and self-efficacy in nature are only partly related to the aforementioned constructs and may not precisely reflect the concepts included in the TPB.

In a cross-sectional study, Malek et al. assessed healthy eating intention and adherence to dietary suggestions using the TPB among pregnant women.[61] They had a similar sample size (n=455) to the present study, and used an online survey to collect the data. Consistent with the present study's findings, they found a significant proportion of the total variance of healthy eating intention was explained by TPB constructs (66%). In contrast, these constructs explained only 3.4% of adherence behavior. Although they used a different approach to analyze associations between the TPB constructs and adherence behavior (regression analysis as opposed to SEM), it was comparable as demonstrated by relatively low correlations between the TPB constructs and inhalation adherence in the present study. This finding indicated that despite the strong association between intention and adherence (as found in the present study), it did not necessarily reflect adequate adherence behavior. In other words, other variables may be affecting the associations between behavioral intention and adherence or external factors that may decrease associations between these two factors.

Wang et al., in the process of developing the IMAS using a confirmatory factor analysis similar to the present study's findings, reported that the four-factor structure of the scale with acceptable fit indices would be applicable to explain intention to inhalation adherence among individuals with COPD.[52] Similar to the findings reported here, they also found that subjective norms and attitudes had the strongest association between intention and other TPB constructs. These findings suggest that although the TPB could be an acceptable framework to clarify factors associated with intention to adherence, due to the significant variance of intention explained by the constructs, any of these constructs may have different impacts in forming the intention. While subjective norms and attitudes may have a similar weight in the formation of intention toward adherence, the PBC significantly indicated a lower weight in this potentially causal relationship.

The evidence from other studies indicates that the situation might be different for various kinds of adherence behavior. Based on the context and type of adherence behavior, the strength of associations between the intention and other TPB constructs may differ. For example, Manning and Bettencourt, in examining the association between depression and medication adherence among survivors of breast cancer, found that attitude had the strongest association with health maintenance plans.[62] In another study designed to explain factors related to adherence to daily physical activity among Chinese adolescents, Zhang et al. found that all three precursors of intention (i.e., attitude, subjective norm, and PBC) with relatively similar strengths were associated with the intention for physical

activity. Moreover, unlike the present study, they did not find any mediating role between the constructs of the TPB and physical activity adherence.[63] Similarly, Lin et al., in the application of the TPB to understand aspirin adherence among Iranian pregnant women, found that despite good fit indices using SEM that were consistent with the present study, PBC had the most significant association with intention.[64] At the same time, this construct showed the least association strength regarding intention for inhalation therapy. These studies confirm the hypothesis that the function of TPB application in explaining different behaviors should be interpreted based on various factors, including type of behavior, target population, setting, and even the cultural context of the society.

As noted in the present study's findings, subjective norms and attitude were the most relevant TPB constructs to intention for inhalation therapy among individuals with COPD. Therefore, any programs designed to improve intention toward adherence should consider these variables as the core factors for the intervention. Perhaps the potential reason for the prominent roles of such variables in defining inhalation intention and adherence, particularly regarding subjective norms, is related to the fact that many individuals with COPD – especially older individuals (which comprised a large proportion of the participants in the present study) – usually need supportive care from their family members or healthcare professionals to use their inhalers proficiently. Therefore, individuals with COPD think the viewpoints of these important others (e.g., their family members and/or healthcare providers) are crucial for any decision to use inhalers adequately and have an accepted adherence to inhalation therapy.

The strong relationship between attitude and subjective norms – also found in the present study – may confirm that these viewpoints directly affect the attitudes of the individuals regarding behavioral intention toward adherence. Therefore, it may be suggested that to enhance such adherence among these individuals, interventions to corroborate positive subjective norms among this population might also lead to promising results. However, this speculation needs further investigation via interventional studies using the TPB among this population. However, small to moderate associations were found between intentions as the precursor of the behavior and the adherence (actual behavior). Although these associations were significant and indicated intentions may be considered as an acceptable predictor of outcome behavior, non-strong relationships between these two variables suggests that any positive or serious intentions toward any potential behavior may not necessarily lead to behavioral occurrence, and there may be other factors that affect such associations. The small to moderate effect sizes between these constructs have also been reported from other health-related behaviors, suggesting that weak to moderate effect sizes are common in the extant literature.[45,46,48,49]

Despite some innovations and strengths included in the study, such as using a standard scale to assess inhalation adherence (i.e., TAIQ), a sufficient sample size to run SEM, and testing the mediation analysis alongside path analysis, there were a number of limitations that should be addressed. First, data were collected from only one hospital using convenience sampling which may reduce the generalizability of the findings to all Taiwanese individuals with COPD. However, by including a sufficient sample size and defining practical inclusion/exclusion criteria, this limitation was mitigated as much as possible. Second, the study only included individuals over 40 years old to have a more homogenous sample, and all of the sample were males. However, as statistics show, COPD may occur among those younger than 40 years, and females may also be at risk of this condition. Therefore, based on age and sex variables, the findings may not apply to younger individuals with COPD or females due to the age/sex dependent nature of psychological variables included in the TPB. Therefore, replication of the study among younger individuals or with more females may produce different results and is suggested for future research. Third, a self-report scale was used to assess the behavioral component of adherence. Therefore, these types of data may be at risk of recall/information biases. Therefore, using an observational checklist for a more accurate examination of the behavior would be helpful to enhance the internal validity of the study. Fourth, the present study used a newly developed measure to assess inhaled medication adherence based on the TPB (i.e., IMAS) which has only been evaluated using basic psychometric techniques, and may need further assessment to confirm robust construct validity. The measure may need further revision of different items such as those related to subjective norms, perceived behavioral control, and intention to provide a more accurate measurement of TPB constructs. Moreover, the present study did not ask about the participants' setting or cultural background, which is important

information for better interpreting the findings and considering their generalizability. Therefore, future studies are warranted to address these issues to improve the current understanding on how these variables may affect adherence behavior. Finally, a traditional version of the TPB, as suggested by Ajzen[54] was used to examine factors associated with intention and adherence. However, other extended/modified versions of the TPB with additional constructs are available that may increase the comprehensiveness of the adherence prediction. Therefore, future studies could use enhanced TPB frameworks to identify other likely important psychological variables that may help better understand behavioral intervention and adherence toward inhalation among these individuals.

CONCLUSION

The present study showed that applying the TPB to explain likely psychological factors involved in inhalation adherence and its intention appears to be useful. Moreover, the findings showed the subjective norms followed by attitude may more significantly explain the outcomes than other TPB constructs. However, these constructs were also inter-correlated. The indirect association of subjective norms with inhalation adherence through intention was also confirmed. Therefore, subjective norms appear to be the most important factor in adhering to inhalation therapy among individuals with COPD. Any programs to enhance inhalation adherence should emphasize the viewpoints and beliefs of important others in the lives of individuals with COPD. Further research is needed using extended/enhanced versions of the TPB using additional constructs such as social support, self-efficacy, and perceived susceptibility among younger individuals, females and/or those living in different cultural contexts.

Human Participants Approval Statement:

Confirmed IRB approval (document number included: 202101706B0C601).

Conflict of Interest Statement:

All authors of this paper declare they have no conflicts of interest.

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Artificial Intelligence (AI) Tools

The authors did not use AI during the entire writing process, except for some grammatical and spelling checks via ChatGPT.

REFERENCES

1. Adeloye D, Song P, Zhu Y, et al. Global, regional, and national prevalence of, and risk factors for, chronic obstructive pulmonary disease (COPD) in 2019: a systematic review and modelling analysis. *Lancet Respir Med*. 2022;10(5):447-58. https://doi.org/10.1016/s2213-2600(21)00511-7
2. Safiri S, Carson-Chahhoud K, Noori M, et al. Burden of chronic obstructive pulmonary disease and its attributable risk factors in 204 countries and territories, 1990-2019: results from the Global Burden of Disease Study 2019. *Bmj*. 2022;378:e069679. https://doi.org/10.1136/bmj-2021-069679
3. Xiang Y, Luo X. Extrapulmonary Comorbidities Associated with Chronic Obstructive Pulmonary Disease: A Review. *Int J Chron Obstruct Pulmon Dis*. 2024;19:567-78. https://doi.org/10.2147/copd.s447739
4. WHO. *Chronic Obstructive Pulmonary Disease (COPD)*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/chronic-obstructive-pulmonary-disease-(copd). Published 6 November 2024. Accessed 7 May 2025.
5. Skajaa N, Laugesen K, Horváth-Puhó E, et al. Comorbidities and mortality among patients with chronic obstructive pulmonary disease. *BMJ Open Respir Res*. 2023;10(1):e001798. https://doi.org/10.1136/bmjresp-2023-001798
6. Sekikawa A, Li M, Joshi N, et al. Much Lower Prevalence and Mortality of Chronic Obstructive Pulmonary Disease in Japan Than in the United States Despite Higher Smoking Rates: A Meta-Analysis/Systematic Review. *J Epidemiol*. 2025;35(2):90-99. https://doi.org/10.2188/jea.je20240085
7. Blanco I, Diego I, Bueno P, et al. Geographic distribution of chronic obstructive pulmonary disease prevalence in Africa, Asia and Australasia. *Int J Tuberc Lung Dis*. 2019;23(10):1100-06. https://doi.org/10.5588/ijtld.19.0015

8. Lim S, Lam DC, Muttalif AR, et al. Impact of chronic obstructive pulmonary disease (COPD) in the Asia-Pacific region: the EPIC Asia population-based survey. *Asia Pac Fam Med*. 2015;14(1):4. https://doi.org/10.1186/s12930-015-0020-9
9. Huang WC, Sheu CC, Hsu JY, et al. The prevalence and clinical features of chronic obstructive pulmonary disease patients with traits of asthma in Taiwan. *J Formos Med Assoc*. 2022;121(1 Pt 1):25-35. https://doi.org/10.1016/j.jfma.2021.01.003
10. Hsieh MH, Lee CT, Tsai PJ, et al. Chronic obstructive pulmonary disease and anxiety disorders: a nationwide population-based study in Taiwan. *Gen Hosp Psychiatry*. 2016;42:1-6. https://doi.org/10.1016/j.genhosppsych.2016.05.005
11. Cortopassi F, Gurung P, Pinto-Plata V. Chronic Obstructive Pulmonary Disease in Elderly Patients. *Clin Geriatr Med*. 2017;33(4):539-52. https://doi.org/10.1016/j.cger.2017.06.006
12. Stenmanns C, Frohnhofen H, Münks-Lederer C, et al. Inhalation treatment of chronic obstructive pulmonary disease (COPD) in older patients. *Z Gerontol Geriatr*. 2025;58(2):97-102. https://doi.org/10.1007/s00391-025-02411-x
13. Wheaton AG, Liu Y, Croft JB, et al. Chronic Obstructive Pulmonary Disease and Smoking Status - United States, 2017. *MMWR Morb Mortal Wkly Rep*. 2019;68(24):533-38. https://doi.org/10.15585/mmwr.mm6824a1
14. Marcus BS, McAvay G, Gill TM, et al. Respiratory symptoms, spirometric respiratory impairment, and respiratory disease in middle-aged and older persons. *J Am Geriatr Soc*. 2015;63(2):251-7. https://doi.org/10.1111/jgs.13242
15. López-Campos JL, Tan W, Soriano JB. Global burden of COPD. *Respirology*. 2016;21(1):14-23. https://doi.org/10.1111/resp.12660
16. Wouters EF, Posthuma R, Koopman M, et al. An update on pulmonary rehabilitation techniques for patients with chronic obstructive pulmonary disease. *Expert Rev Respir Med*. 2020;14(2):149-61. https://doi.org/10.1080/17476348.2020.1700796
17. Morley JE. Chronic obstructive pulmonary disease: a disease of older persons. *J Am Med Dir Assoc*. 2014;15(3):151-53. https://doi.org/10.1016/j.jamda.2013.12.078
18. Hendrychova T, Svoboda M, Maly J, et al. Self-Reported Overall Adherence and Correct Inhalation Technique Discordance in Chronic Obstructive Pulmonary Disease Population. *Front Pharmacol*. 2022;13:860270. https://doi.org/10.3389/fphar.2022.860270
19. Delamater AM. Improving Patient Adherence. *Clin Diabetes*. 2006;24(2):71-77. https://doi.org/10.2337/diaclin.24.2.71
20. WHO. *Adherence to Long-term Therapies: Evidence for Action*. World Health Organization 2003. https://iris.who.int/handle/10665/42682
21. Valladales-Restrepo LF, Oyuela-Gutiérrez MC, Delgado-Araujo AC, et al. Adherence to Inhalation Devices in Patients with Chronic Obstructive Pulmonary Disease. *Patient Prefer Adherence*. 2023;17:3233-44. https://doi.org/10.2147/ppa.s432808
22. Vauterin D, Van Vaerenbergh F, Grymonprez M, et al. Medication adherence to inhalation therapy and the risk of COPD exacerbations: a systematic review with meta-analysis. *BMJ Open Respir Res*. 2024;11(1):e001964. https://doi.org/10.1136/bmjresp-2023-001964
23. Kvarnström K, Westerholm A, Airaksinen M, et al. Factors Contributing to Medication Adherence in Patients with a Chronic Condition: A Scoping Review of Qualitative Research. *Pharmaceutics*. 2021;13(7):1100. https://doi.org/10.3390/pharmaceutics13071100
24. Intilangelo A, Majic S, Palchik V, et al. [Translated article] Validated questionnaires on medication adherence and associated factors in chronic patients: A systematic review. *Farm Hosp*. 2024;48(4):T185-t92. https://doi.org/10.1016/j.farma.2024.04.019
25. Chen Y, Gao J, Lu M. Medication adherence trajectory of patients with chronic diseases and its influencing factors: A systematic review. *J Adv Nurs*. 2024;80(1):11-41. https://doi.org/10.1111/jan.15776
26. Ling RZQ, Jiao N, Hassan NB, et al. Adherence to diet and medication and the associated factors among patient with chronic heart failure in a multi-ethnic society. *Heart Lung*. 2020;49(2):144-50. https://doi.org/10.1016/j.hrtlng.2019.11.003
27. Murphy VE, Robijn AL, Metcalfe TB, et al. Beliefs about medicines and adherence to asthma medications during pregnancy. *J Asthma*. 2023;60(7):1446-54. https://doi.org/10.1080/02770903.2022.2155185

28. Zolnierek KB, Dimatteo MR. Physician communication and patient adherence to treatment: a meta-analysis. *Med Care*. 2009;47(8):826-34. https://doi.org/10.1097/mlr.0b013e31819a5acc
29. Jia Y, Wang H, Zhang Z, et al. Parenting style and child asthma control in families of school-age children with asthma: The mediating effects of children's general self-efficacy and medication adherence. *J Pediatr Nurs*. 2023;73:e293-e301. https://doi.org/10.1016/j.pedn.2023.09.025
30. Joël L, El Badrawy M, Nofal A, et al. A cohort study of medication adherence among patients with chronic obstructive pulmonary disease in Egypt. *NPJ Prim Care Respir Med*. 2020;30(1):31. https://doi.org/10.1038/s41533-020-0188-9
31. Zheng L, Sun H, Chen Q, et al. Influential factors of adherence to inhalation drug therapy in patients with stable chronic obstructive pulmonary disease. *J Eval Clin Pract*. 2025;31(1):e14094. https://doi.org/10.1111/jep.14094
32. Kardas P, Lewek P, Strzondała M. Adherence to treatment in asthma and COPD patients in their doctors' assessment. *Pneumonol Alergol Pol*. 2015;83(6):436-44. https://doi.org/10.5603/piap.2015.0072
33. Han M, Fu Y, Ji Q, et al. The effectiveness of theory-based smoking cessation interventions in patients with chronic obstructive pulmonary disease: a meta-analysis. *BMC Public Health*. 2023;23(1):1510. https://doi.org/10.1186/s12889-023-16441-w
34. McDermott MS, Oliver M, Simnadis T, et al. The Theory of Planned Behaviour and dietary patterns: A systematic review and meta-analysis. *Prev Med*. 2015;81:150-6. https://doi.org/10.1016/j.ypmed.2015.08.020
35. Prusiński T. The Role of Doctor's Authority in Patients' Treatment Decisions. *Am J Health Behav*. 2022;46(5):503-14. https://doi.org/10.5993/ajhb.46.5.2
36. Tyler T, Mentovich A, Satyavada S. What Motivates Adherence to Medical Recommendations? The Procedural Justice Approach to Gaining Deference in the Medical Arena. *Regul Gov*. 2014;8(3):350-70. https://doi.org/10.1111/rego.12043
37. Ajzen I. The theory of planned behaviour: reactions and reflections. *Psychol Health*. 2011;26(9):1113-27. https://doi.org/10.1080/08870446.2011.613995
38. Glanz K, Rimer BK, Viswanath K. *Health Behavior and Health Education: Theory, Research, and Practice*. 4th ed. Jossey-Bass/Wiley 2008.
39. Wu L, Li X, Ismail HN, et al. Understanding the psychosocial dilemma in breastfeeding: a narrative review of extended theory of planned behavior and its intervention strategies. *Reprod Health*. 2025;22(1):46. https://doi.org/10.1186/s12978-025-02001-5
40. Adams C, Gringart E, Strobel N. Explaining adults' mental health help-seeking through the lens of the theory of planned behavior: a scoping review. *Syst Rev*. 2022;11(1):160. https://doi.org/10.1186/s13643-022-02034-y
41. Hackman CL, Knowlden AP. Theory of reasoned action and theory of planned behavior-based dietary interventions in adolescents and young adults: a systematic review. *Adolesc Health Med Ther*. 2014;5:101-14. https://doi.org/10.2147/ahmt.s56207
42. Riebl SK, Estabrooks PA, Dunsmore JC, et al. A systematic literature review and meta-analysis: The Theory of Planned Behavior's application to understand and predict nutrition-related behaviors in youth. *Eat Behav*. 2015;18:160-78. https://doi.org/10.1016/j.eatbeh.2015.05.016
43. Lareyre O, Gourlan M, Stoebner-Delbarre A, et al. Characteristics and impact of theory of planned behavior interventions on smoking behavior: A systematic review of the literature. *Prev Med*. 2021;143:106327. https://doi.org/10.1016/j.ypmed.2020.106327
44. Leung KM, Wong MY, Ou KL, et al. Assessing Esports Participation Intention: The Development and Psychometric Properties of the Theory of Planned Behavior-Based Esports Intention Questionnaire (TPB-Esport-Q). *Int J Environ Res Public Health*. 2021;18(23):12653. https://doi.org/10.3390/ijerph182312653
45. Al-Sarray RAH, Shamshiri A, Alzubidi M, et al. Development and psychometric evaluation of a theory of planned behavior model-based instrument for evaluation of determinants of oral health behaviors in mothers of children younger than six years in Iraq. *BMC Oral Health*. 2025;25(1):181. https://doi.org/10.1186/s12903-025-05566-6
46. Caro-Bautista J, Espinar-Toledo M, Villa-Estrada F, et al. Development and Psychometric Validation of an Instrument to Identify Barriers to Self-Care Among Spanish Patients With Type 2 Diabetes on the Basis of Theory of Planned Behavior. *Value Health*. 2019;22(9):1033-41. https://doi.org/10.1016/j.jval.2019.04.1921

47. Ritchie D, Van den Broucke S, Van Hal G. The health belief model and theory of planned behavior applied to mammography screening: A systematic review and meta-analysis. *Public Health Nurs*. 2021;38(3):482-92. https://doi.org/10.1111/phn.12842
48. Meis LA, Noorbaloochi S, Hagel Campbell EM, et al. A Theory of Planned Behavior Scale for Adherence to Trauma-Focused Posttraumatic Stress Disorder Treatments. *J Trauma Stress*. 2021;34(2):440-53. https://doi.org/10.1002/jts.22620
49. Al-Rajabi OZ, Abushaikha LA, Al Hadid LA. Development and Validation of the Immediate Postpartum Care Adherence Questionnaire: An Application of the Theory of Planned Behavior among Healthcare Professionals. *Iran J Nurs Midwifery Res*. 2024;29(6):669-77. https://doi.org/10.4103/ijnmr.ijnmr_157_22
50. Chevance G, Héraud N, Varray A, et al. Change in explicit and implicit motivation toward physical activity and sedentary behavior in pulmonary rehabilitation and associations with postrehabilitation behaviors. *Rehabil Psychol*. 2017;62(2):119-29. https://doi.org/10.1037/rep0000137
51. Ricke E, Dijkstra A. Determinants of Exercise Adherence in a Prospective Cohort Study of Patients With Chronic Obstructive Pulmonary Disease: An Application of the Theory of Planned Behavior and the Concept of Alliance. *Med Res Arch*. 2023;11(8):1-11. https://doi.org/10.18103/mra.v11i8.4346
52. Wang YH, Yang TM, Hung MS, et al. The Intention of Inhaled Medication Adherence Scale (IMAS): The Development of a New Instrument for Assessing Inhaled Medication Adherence Among Patients with Chronic Obstructive Pulmonary Disease (COPD) Using Theory of Planned Behavior. *Int J Chron Obstruct Pulmon Dis*. 2023;18:1655-64. https://doi.org/10.2147/copd.s420001
53. Sharma M, Joshi S, Banjade P, et al. Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2023 Guidelines Reviewed. *Open Respir Med J*. 2024;18:e18743064279064. https://doi.org/10.2174/0118743064279064231227070344
54. Ajzen I. The Theory of Planned Behavior. *Organ Behav Hum Decis Process*. 1991;50(2):179-211. https://doi.org/10.1016/0749-5978(91)90020-T
55. Plaza V, Fernández-Rodríguez C, Melero C, et al. Validation of the 'Test of the Adherence to Inhalers' (TAI) for Asthma and COPD Patients. *J Aerosol Med Pulm Drug Deliv*. 2016;29(2):142-52. https://doi.org/10.1089/jamp.2015.1212
56. Meng WW, Cui YN, Luo LJ, et al. [Reliability and validity of the Chinese version of the test of the adherence to inhalers (TAI)]. *Zhonghua Jie He He Hu Xi Za Zhi*. 2022;45(5):423-30. https://doi.org/10.3760/cma.j.cn112147-20211108-00783
57. Li CH. Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behav Res Methods*. 2016;48(3):936-49. https://doi.org/10.3758/s13428-015-0619-7
58. Hu LT, Bentler PM. Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. *Struct Equ Modeling*. 1999;6(1):1-55. https://doi.org/10.1080/10705519909540118
59. Lin CY, Updegraff JA, Pakpour AH. The relationship between the theory of planned behavior and medication adherence in patients with epilepsy. *Epilepsy Behav*. 2016;61:231-36. https://doi.org/10.1016/j.yebeh.2016.05.030
60. Yang Z, Jia H, Wang A. Predictors of home-based cardiac rehabilitation exercise adherence among patients with chronic heart failure: a theory-driven cross-sectional study. *BMC Nurs*. 2023;22(1):415. https://doi.org/10.1186/s12912-023-01566-5
61. Malek L, Umberger WJ, Makrides M, et al. Predicting healthy eating intention and adherence to dietary recommendations during pregnancy in Australia using the Theory of Planned Behaviour. *Appetite*. 2017;116:431-41. https://doi.org/10.1016/j.appet.2017.05.028
62. Manning M, Bettencourt BA. Depression and medication adherence among breast cancer survivors: bridging the gap with the theory of planned behaviour. *Psychol Health*. 2011;26(9):1173-87. https://doi.org/10.1080/08870446.2010.542815
63. Zhang R, Zhang CQ, Gu D. Integrating perceived physical environments and the theory of planned behaviors when explaining adherence to 24-hour movement guidelines in Chinese adolescents. *Scand J Med Sci Sports*. 2024;34(1):e14530. https://doi.org/10.1111/sms.14530
64. Lin CY, Broström A, Nilsen P, et al. Using extended theory of planned behavior to understand aspirin adherence in pregnant women. *Pregnancy Hypertens*. 2018;12:84-89. https://doi.org/10.1016/j.preghy.2018.04.001