

Original Research Article

Exploring and validating performance measurement domains of community pharmacists using structural equation modeling: implications and recommendations for research

ABSTRACT

Background

Structural equation modeling (SEM) is a widely used quantitative technique among social and management science researchers. Self-reported questionnaires are in prevalent use among researchers in pharmacy management. But validity and measurement invariance measures of questionnaires are not commonly reported research.

Objectives

To determine the construct validity and invariance validity of the research instrument. To provide guidelines for applying confirmatory factor analysis (CFA) in pharmacy management research.

Method

A cross-sectional study with an anonymously structured questionnaire randomly administered to six hundred community pharmacists in southwestern, Nigeria. The CFA algorithm in structural equation modeling (SEM) software was used to develop a measurement model and test hypotheses.

Results

The measurement model satisfied the model and construct validity benchmarks. The measurement invariance parameters were adequate.

Conclusion

The study concluded that the theoretically developed constructs- economic, operational, and social performance were valid representations of theory. Mandatory inclusion of validity and measurement invariance test reporting in pharmacy management research is advocated.

Keywords

Behavioral research, confirmatory factor analysis, social pharmacy, measurement invariance, model fit, structural equation modeling, pharmacy management

INTRODUCTION

~~Structural equation modeling (SEM) techniques have~~The use of structural equation modeling (SEM) techniques has achieved huge popularity and applicability in research in several disciplines, such as psychology, administrative sciences, management science, marketing, ecology, and sociology. Several authors have provided guidelines and recommendations on the use of SEM in evaluating the validity of constructs and models (Ali ~~et al~~ *et al.*, 2018; Henseler~~et al~~ *et al.*, 2009; Fan ~~et al~~ *et al.*, 2016; Alavi, 2013; Hair ~~et al~~ *et al.*, 2014; Hair *et al.*, 2012; Henseler~~et al~~ *et al.*, 2016; Lowry & Gaskin, 2014; Sarstedt *et al.*, 2012). However, the availability of guidelines for the use of SEM among researchers in social, behavioral, and administrative pharmacy is still nascent and evolving (Schreiber *et al.*, 2006; Schreiber, 2017; Carter, 2016; Oamen *et al.*, 2022). SEM is a group of multivariate quantitative statistical techniques with a broad range of capabilities for developing and testing relationships between variables. They are beneficial for small sample sizes, the robustness of research findings, and for creating and authenticating a *priori* theoretical models (Bryne, 2010; Collier, 2020). SEM provides more robust estimations of variables and parameters compared to linear and multiple regression methods. Although there is limited use of SEM in pharmacy research, existing studies tend to omit or do not report model fit evaluation, construct validity measures, and measurement invariance estimations (Lowry & Gaskin, 2014; Henseler *et al.*, 2016).

Structural equation models enable researchers to provide a robust analysis of possible multivariate relationships between variables in research, in which assessment of knowledge, attitudes, and perception (KAP) of respondents is essential. Hence, researchers must ensure parsimony, measurement adequacy, and theoretically valid constructs. Therefore, the use of confirmatory factor analysis (CFA) and measurement invariance is a suggested methodology to adopt (Brown, 2015; Oamen, 2021; Schreiber *et al.*, 2006; Carter, 2016). Measurement invariance testing is a core requirement in cases of instrument bias suspicion and in situations where data is collected over two-time points (longitudinal studies). This is of particular relevance because most studies in social pharmacy are targeted at informing practice and policy (Oamen *et al.*, 2022; Putnick & Bornstein, 2016). Therefore, policymakers are keen to have empirical evidence that is valid and generalizable. This strengthens the need for invariance and CFA studies. This study ~~used multigroup structural equation modeling by using multigroup structural equation modeling~~

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~~aimed~~ to validate the performance domains of community pharmacists and also measure the equivalence of the measures across gender subgroups of the study population.

The applicability of SEM to KAP and longitudinal studies in pharmacy practice provides more impactful results or estimations as it considers the contribution of the indicator items responsible for a construct. This is ~~opposed to~~ different from the traditional method of creating composites of indicators to form constructs for regression analysis (Lowry & Gaskin, 2014; Henseler *et al*, 2016).

Performance management evaluation among community pharmacists

Performance evaluation among community pharmacists is an evolving area, ~~therefore;~~ therefore it is relevant to have well-developed and replicable performance assessment measures. That may apply to both individual and group assessments. From extant literature, performance measures comprise three main themes: a) economic performance measures, b) social performance measures, and c) operational performance measures. The economic performance measures are associated with monetary and financial indicators or outcomes influencing businesses, such as sales revenue growth, turnover rates, profitability, resource availability, and expense control (Meressa, 2020; Cavicchi & Vagnoni, 2020; Ranghchian *et al*, 2018; Oamen & Lawal, 2023). Social performance measures or outcomes address the impact of the business on society, social relations with local communities they serve, and customer acquisition and retention. The key indicators include business collaboration, customer satisfaction, customer engagement, and customer loyalty (Ranghchian *et al*, 2018; Wiklund & Shepherd, 2005; Chang & Chi, 2007; Miller *et al*, 2012). Operational performance measures address the factors influencing the effectiveness and efficiency of daily work operations in the community pharmacy such as technology utilization to improve operational efficiency, procedural efficiency in inventory use and control, and optimization of daily workflow operations (Ranghchian *et al*, 2018; Wiklund & Shepherd, 2005; Chang & Chi, 2007). Consequently, to enhance the applicability and use of measurement scales, there is the need to ascertain the theoretical (*apriori*) basis of performance domains of community pharmacists as developed from literature using confirmatory factor analysis (CFA).

Therefore, the purpose of the study is to 1) determine the model fit, construct validity (convergent and discriminant), and invariance validity of the self-reported performance measures of

community pharmacists: 2) To provide basic guidelines and recommendations for applying confirmatory factor analysis in pharmacy practice research using SEM.

Hypotheses Development

Confirmatory Factor Analysis and Construct Validity

CFA in SEM is useful for confirming the factor structure of exploratory factor analysis and *a priori* measures of constructs (Schreiber, 2020; Oamen, 2021). CFA estimates provide model fit estimates that confirm the hypothetical model as being a true reflection of the sample population. Typically, fit indices are expressed as square root mean ratio (SRMR) and root mean square error of approximation (RMSEA) with recommended cutoff at $p < 0.08$ and other goodness of fit (GoF) measures to ascertain the fit of the model to the data (Henseler *et al.*, 2015; Henseler *et al.*, 2016). CFA is a requirement to assess construct validity (convergent and divergent validity measures) because a statistically fit model does not imply a valid model. Convergent validity measures include reliability coefficients such as composite reliability (CR), average variance explained (AVE), and Cronbach alpha.

On the other hand, divergent validity seeks to establish that the constructs being measured are independent or separate from other constructs (no presence of overlapping meanings). Here, Fornell & Larcker and Heterotrait-Monotrait (HTMT) criteria estimates provide clarity and separability of constructs. Here, the square root of the AVE of the constructs should be higher than the correlations between the constructs. HTMT is a current improvement on Fornell & Larcker criterion, as it is sensitive and more robust to the distinctiveness of constructs using a correlation matrix (Henseler *et al.*, 2015; Henseler *et al.*, 2016).

H1: *There is an adequate model fit of the measurement model*

H2: *There is construct validity of the research instrument [constructs or latent variables]*

Measurement Invariance Criterion

Measurement Invariance testing is a statistical measure used to determine if the measurement instrument is conceptually understood equivalently across subgroups of the study or target population (Bryne, 2010; Cheung & Rensvold, 2002; Putnick & Bornstein, 2016). Measurement invariance algorithm in analysis of moment structures (AMOS; Arbuckle, 2014) software enables

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researchers to confirm if researcher questions are equally understood by subgroups in the target population.

Oamenet *al* (2022) advocated the incorporation of measurement invariance testing and reporting in pharmacy practice research studies. This is salient considering that developed research questionnaires are used to elicit opinions and perceptions from heterogeneous populations as well as homogeneous groups. Thus, it is important to ascertain that the questionnaire items are equivalently or similarly understood by the different subgroups in the study population. This eliminates the possibility of the instrument and reporting bias (Oamenet *al*, 2022).

Measurement invariance criteria were based on chi-square test statistic/degree of freedom (χ^2/df), Comparative Fit Index (CFI), Tucker Lewis Index (TLI), root mean square error of approximation (RMSEA) measures for configural invariance. And subsequent analysis requires the absolute change in comparative fit index (ΔCFI) to be less than 0.01 difference between models for metric, scalar, and residual invariance using configural invariant model as a baseline (Bryne, 2010; Cheung & Rensvold, 2002; Oamenet *al*, 2022).

H3: *There is measurement invariance or equivalence of the research instrument [configural, metric, scalar, and residual invariance] between male and female respondents.*

Abbreviations:

EFA=exploratory factor analysis, CFA=confirmatory factor analysis, GoF=goodness of fit, SRMR=square root mean ratio, RMSEA=root mean square error of approximation, SEM=structural equation modeling, CFI=comparative fit indices, TLI=tucker fit indices, CR=composite reliability, AVE=average variance explained, HTMT=HeterotraitMonotrait, KAP=knowledge, Attitude, and Practice, CB-SEM=covariance based structural equation modeling, MI=measurement invariance, Δ =absolute change or difference

METHOD

A cross-sectional, self-reported questionnaire-based study involving 600 practicing community pharmacists situated in the southwestern part of Nigeria using the simple random sampling method. Data collection took place between July to October 2022. The optimal sample size adequate for a structural equation modeling study was computed using Daniel Soper calculators for SEM studies (Soper, 2022). The *a-priori* calculator was computed based on the number of

latent variables (n=3), the number of observed or indicator variables (n=9), the probability at 1%, moderate effect size (0.2), and the statistical power of 80%. (Soper, 2022) The recommended sample size was 404 is required to achieve valid and reliable SEM results. However, a larger sample population of 600 was obtained to achieve the generalizability and robustness of the results. Informed consent was obtained from respondents before the administration of the questionnaire. As a self-reported study, the perspective of analysis was based on the perception of the community pharmacist. The STROBE checklist for reporting cross-sectional studies was adopted for the reporting of this paper (Von *et al*, 2007).

Measurement and Operationalization of Variables

Performance Measures (PMS) were measured using a 5-point Likert scale structure- very good (1), above average (4), average (3), below average (2), and very poor (1). Based on theory, the economic performance domain was measured by measurement items: growth of sales revenue in the last 1 year (PMS1); improvement in profitability in the last 1 year (PMS2); and reduction of overhead and expenses in the last 1 year (PMS3) (Cavicchi&Vagnoni, 2020; Merissa *et al*, 2020).Operational performance was measured by 3 indicators- improvement in work operations using technology (PM5); accuracy and reliability of inventory management processes (PM6); efficiency and effectiveness of daily work operations (PM7) (Wiklund& Shepherd, 2005; Chang & Chi, 2007). Social performance was also measured by 3 indicators- an improved collaboration with colleagues in the past 1 year (PMS4); growth in my client's satisfaction in the last 1 year (PMS8), and level of customer loyalty in the past 1 year (PMS9) (Ranghchianet *al*, 2018; Purbowoet *al*, 2022; Jose *et al*, 2022).

Data Analysis

Confirmatory factor analysis was to examine model fit, construct validity, and measurement invariance characteristics of the study model using Analysis of Moment Structures (AMOS) software version 24 using a maximum likelihood estimator (Arbuckle, 2014). AMOS software is a CB-SEM software for executing path model estimations.

Ethical Approval

Ethical approval with approval number HPRS/381/477 dated 22nd July 2022, was obtained from the Department of Health Planning, Research, and Statistics, Ministry of Health, Ogun State,

Nigeria. Informed consent was obtained from respondents before the administration of the questionnaire.

RESULTS

Response rate and Demographic Characteristics of Respondents

A total of 600 completed questionnaires were obtained out of 700 administered (response rate of 85.7%). A majority of the community pharmacists sampled were male (n=329, 54.8%) and female (n=271, 45.2%). The bulk of respondents is aged between 31-40 years (n=227, 37.8%) while 204 (34%) were aged above 40 years. The model of ownership revealed that a majority were sole proprietors (n=294, 49%), followed by partnership (n=84, 14%), and pharmacist managers (n=222, 37%). Finally, 416 (69.3%) had between 1 to 10 years of community pharmacy practice experience, followed by 11 to 15 years (n=121, 20.2), and 63 (10.5%) had greater than 20 years of practice experience.

Common Method Bias

Common method bias (CMB) of self-reported measures was conducted to determine if the questionnaire or data collection instrument using a common Likert scale format introduced bias based on respondents' tendency to give similar responses to all the questions. (Tehseen *et al*, 2017) Harman's one-factor method was used and the CMB value was 49.18% which is less than the 50% cutoff value (Aguirre-Urreta & Hu, 2019; Kock, 2020). Hence, the dataset is suitable for further analysis.

Model fit and Modification of the Measurement model

The initial model presented with poor model fit indices; hence the measurement model was modified using the suggestions presented in the modification indices platform in the statistical software. The modification of the model was implemented by covarying the error terms of related indicators based on strong theoretical foundations involving only the indicators of the same construct. In this model, modification linkages were drawn between the error terms of PMS4 and PMS8 (e9 and e8) and PMS4 and PMS9 (e9 and e7) of the social performance construct. Also, similar linkages were drawn from the error terms of PMS5 and PMS7 (e6 and e4) of the operational performance construct as shown in **Figure 1**. The modification of the measurement model was informed by the modification indices suggested by the software and relevant theoretical underpinnings (Schreiber *et al*, 2006; Arbuckle, 2014; Collier, 2020). The linkages of

the error terms between indicators were justified based on; 1] the fact that the collaborative attitude of community pharmacists (PMS4) is associated with improved clients' satisfaction and loyalty denoted by PMS8 and PMS9 respectively (Ranghchian *et al*, 2018). Similarly, workflow improvement (PMS5} is related to enhanced efficiency and effectiveness of pharmacy operations (Wiklund & Shepherd, 2005).

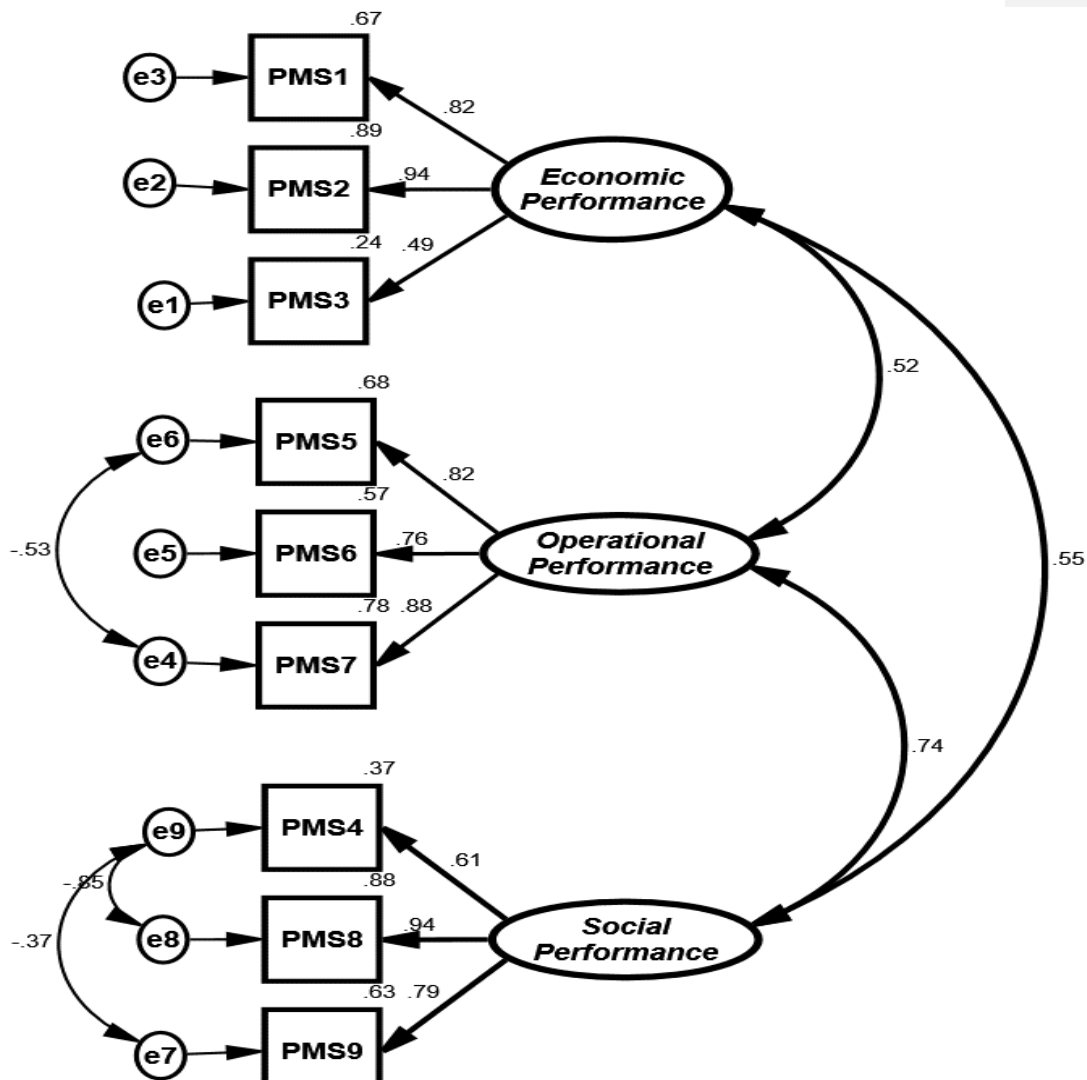


Figure 1. Measurement Model showing standardized factor loadings and Covariance
Evaluation of Model fit

The model fit estimates showed the ratio of chi-square test/degree of freedom; $\chi^2/df=4.468$ ($\chi^2=93.827$, degrees of freedom $df=21$) which is less than the benchmark of 5: RMSEA=0.076 which is below the cutoff value of 0.08. The SRMR value of 0.037 was adequate compared to the cutoff value of 0.08. The goodness of fit (GoF) indices of the hypothetical model was comparative fit index (CFI) of 0.972, Tucker Lewis index (TLI)= 0.952 (all above the strict benchmark value of 0.95) (Hu & Bentler, 1999; Kline, 2016). Hence, hypothesis (H1) was supported which implies that the hypothesized model is representative of the target population.

Table 1
Internal reliability coefficients (convergent validity) of indicators and constructs

Construct	Description	Factor loading*	CR	Cronbach	AVE
Indicators					
Economic Performance			0.807	0.768	0.598
PMS1	Growth in yearly sales revenue	0.817			
PMS2	Increased yearly profit	0.944			
PMS3	Reduced cost of doing business	0.486			
Operational Performance			0.861	0.834	0.674
PMS5	Improved workflow	0.824			
PMS6	Optimal stock management	0.755			
PMS7	Improved work efficiency	0.88			
Social Performance			0.831	0.714	0.628
PMS4	Collaborative work	0.611			
PMS8	Enhanced customer satisfaction	0.937			
PMS9	Enhanced client loyalty	0.795			

* Standardized, CR=composite reliability, AVE=average variance explained

Table 1 above, it showed that apart from PMS4 and PMS6, the standardized factor loadings of each indicator constituting each construct had values above 0.7. The decision criteria to accept indicators with factor loadings below 0.7 was based on two reasons: firstly, the researcher is at liberty can retain items below the value if they do not lower the CR and AVE values of the latent construct, and secondly, if it makes theoretical sense to retain the item (Collier, 2020; Schreiber et al, 2006).

Assessment of Measurement Model Reliability and Validity

The measurement model was then assessed for convergent and discriminant validity. To establish convergent validity, composite reliability (CR) and Cronbach alpha values for the constructs

must be above the benchmark of 0.7 and the average variance explained (AVE) above the baseline of 0.5 for the three constructs as shown in Table 1. Hence, convergent validity was established since the criteria were met.

To establish discriminant validity, the model was evaluated using Fornell& Larcker and Heterotrait Monotrait (HTMT) criteria as shown in Table 2. The HTMT ratio is less than the threshold of 0.9. While for Fornell& Larcker criterion, the square root of the AVE was greater than the inter-construct correlations. Hence, the Fornell& Larcker criteria were equally satisfied (Henseler *et al.*, 2016; Hu & Bentler, 1999). Therefore, hypothesis (H2) is supported by the study findings.

Table 2.
Discriminant Validity of Measurement Model

Constructs	Fornell& Larcker			Heterotrait Monotrait		
	1	2	3	1	2	3
1 Economic	0.773*					
2 Operational	0.520	0.821*		0.585		
3 Social	0.546	0.737	0.792*	0.704	0.877	

*Denoted the square root of the AVE along the diagonal

Evaluation of Measurement Invariance

The multigroup confirmatory factor analysis was used to assess measurement invariance validity of the questionnaire to establish-1] actual uniformity of understanding of the instrument by respondents based on the major grouping variable-Gender, and, 2] to provide a basis for realistic and valid group comparisons across gender (Cheung & Rensvold, 2002; Byrne, 2004; Oamenet *al*, 2022). Results revealed configural invariance (denoted as B1) across each group with satisfactory goodness of fit indices: χ^2/df , CFI, TLI, RMSEA. This implies that the model structure is equal, equivalent, or invariant across each group. Furthermore, as shown in Table 3, metric (B2), scalar (B2) and residual (B3) invariance measures were also established based on gender (B2: $\Delta CFI=0.002$; B3: $\Delta CFI=0.001$; B4: $\Delta CFI=0.003$).

Table 3.
Measurement Invariance testing across Gender (Female-271, Male-329, N=600)

Model	RMSEA	χ^2/df	CFI	TLI	Model	ΔCFI	ΔTLI	Hypothesis
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					diff.		(H3)
B1: configural	0.055	2.839	0.971	0.950	0	0	supported
B2: metric	0.052	2.620	0.971	0.956	B1	0.000	supported
B3: scalar	0.047	2.312	0.972	0.964	B2	0.001	supported
B4: residual	0.045	2.216	0.970	0.967	B3	0.002	supported

* Δ =absolute difference of less than 0.01 between models is acceptable

The results as shown in Table 3 showed that the performance questionnaire had configural, metric, scalar, and residual invariance based on gender. This is confirmed by model fit attributes being less than 0.01 baseline absolute difference. Therefore, hypothesis **H3** was supported. This implies that the measurement or research instrument was equivalently understood by male and female community pharmacists.

DISCUSSION

The study empirically tested the model fit, construct, and invariance validity of the theoretical questionnaire of self-reported performance of community pharmacists using the CB-SEM algorithm in AMOS.

The findings of the study were obtained using the illustrative step-by-step procedure for establishing the validity of theoretically developed constructs. The performance domains of community pharmacists-economic, operational, and social aspects were confirmed to be valid representations of theory as shown in Tables 1 and 2(Oamen& Lawal, 2023). This supports and opens more opportunities for the discovery of relationships that hitherto were not easily accessed. Furthermore, researchers are afforded the tools to capture causal relationships and determine the measures contributing to the effects. This is preferable compared to the use of composite scores of constructs that aggregate factor scores without due consideration for the effect of individual contributors.

Furthermore, KAP studies in pharmacy practice research would benefit from increased adoption of these techniques for three main reasons: firstly, improved extrapolation of findings to the general population. Secondly, a graphical display of results enables quick comprehension, and thirdly, the validity and reliability of constructs can be consistently estimated. Finally, longitudinal studies would benefit from CFA to validate instruments used over several time points.

The confirmation of measurement invariance of research instruments or questionnaires is of paramount relevance to researchers in pharmacy practice. This is revealed by the model showing adequate configural, metric, scalar, and residual invariance measures as shown in Table 3. This is because it establishes the suitability and applicability of the developed tool to assess perception based on gender which was the major grouping variable in this study (Oamen et al, 2022; Putnick & Bornstein, 2016). This can be extended to other grouping variables covering demographic and cross-cultural characteristics such as tribe, region, country, health status, financial status, and years of experience amongst others. In other words, measurement variance or inequivalence is avoided. This measurement invariance or inequivalence introduces biased estimates and inference errors particularly if the distribution of demographic characteristics is disproportionately skewed to one attribute compared to the other (Hair et al., 2010; Milfont & Fischer, 2010; Putnick & Bornstein, 2016). The study using SEM provided additional evidence for researchers in pharmacy practice to support scale validation and the application of CFA to validate constructs in social and administrative pharmacy research.

Implications and recommendation of the study to research

Based on study outcomes, the following considerations are recommended for researchers in pharmacy practice:

1. The use of CFA is essential to confirm the validity of the factor structure of constructs developed from a priori theory, and the output of exploratory factor analysis (Schreiber et al, 2006; Carter, 2016; Oamen et al, 2022).

Furthermore, the estimation of model fit (modification indices) provides the basis for model trimming in which indicators or items that do not contribute significantly to the constructs are removed to achieve an optimal model fit and a more parsimonious model (Byrne, 2010; Collier, 2020). Hence, respondents are given fewer questions compared to multiple questions in less parsimonious models.

2. Furthermore, establishing convergent and discriminant validity of latent variables or constructs is required to ensure the separability of indicators and constructs. Hence, the validity and uniqueness of research questionnaires are maintained (Henseler et al, 2015).

3. For studies involving questionnaires involving demographic subgroups, pretest and posttest measures, or data collected over two-time points, it is essential to establish measurement

invariance to ascertain the consistency or equivalence in the understanding of the tool used by the respondents. (Schreiber, 2020)

4. CFA is also applicable for establishing the validity of a research instrument in another cultural group although validated in a different culture (Cheung, 2009; Kline, 2016).

Limitations of the study

Although the study affords the brevity of measurement, there is ample room for other performance measures to explore other domains. The study is cross-sectional in design, so there is a need to run a longitudinal study to evaluate potential changes in perception over time. Furthermore, the CB-SEM algorithm was executed using AMOS software. However, variance-based SEM or partial least squares SEM in software such as; WarpPLS[®], and SMART PLS[®] could be used for executing confirmatory factor analysis and model validation (Kock, 2022; Ringle *et al.*, 2022).

CONCLUSION

Based on the evidence provided by the study, it is concluded that the theoretically developed constructs- economic, operational, and social performance domains were adequate and valid representations of the theory. Measurement Invariance testing affirmed comprehension of the tool by respondents across gender. Furthermore, it reinforces the need for researchers involved in scale development and questionnaire development to include the assessment of measurement invariance in their methodological process. The results of the study add substantially to questionnaire development and use in pharmacy practice research. The study recommends the mandatory inclusion of validity and measurement invariance tests in pharmacy practice research. The application of measurement invariance measures in questionnaire development is essential to generating valid and generalizable scales.

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