of the patients completed the nine steps. Significantly greater percentage of DPI users completed the nine-step technique compared with pMDI users ($P = 0.04$), as shown in Table 2.

When subjects that completed the nine-step inhaler technique for the pMDI were compared with those that did not complete the nine steps, those with tertiary educational qualifications ($P < 0.01$) and those with monthly asthma symptoms ($P < 0.01$) were more likely to use the inhaler technique more accurately than their counterparts [Table 3].

For the DPI, those who felt they were confident on the use of inhalers ($P = 0.03$) and those who had previously received instructions on how to use the inhalers from a doctor ($P < 0.01$ were more likely complete the steps of the technique than their corresponding counterparts [Table 4].

When the variables that were significantly associated with completion of the different inhaler technique were subjected to logistic regression analysis, higher educational status was the only significant predictor of completion of pMDI inhalation technique ($P < 0.001$, odds ratio = 5.058, confidence interval 2.005-12.758) as shown in Table 5. Those with higher education were more likely to complete the technique.

## Discussion

This observational study of 140 asthmatic patients showed that the vast majority of patients use their inhalers incorrectly,

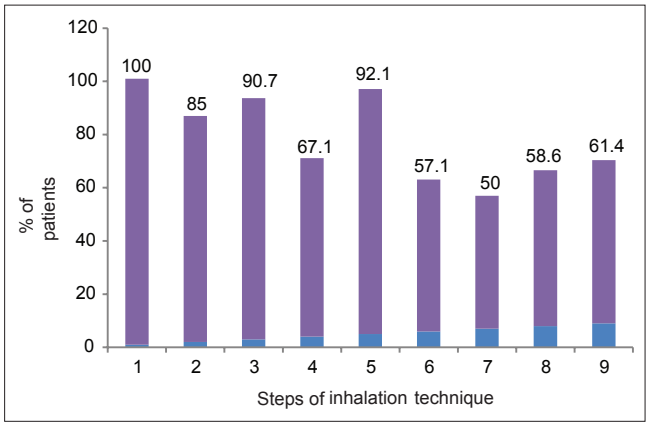


**Figure 1:** Percentage of patients that performed each step of pressurized metered dose inhalers inhaler technique

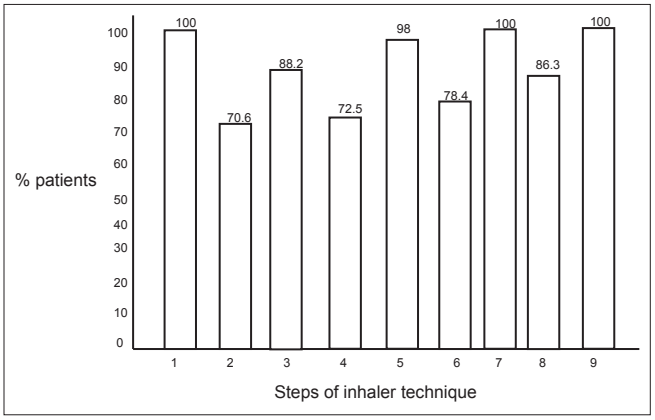


**Figure 2:** Percentage of patients that performed each step of dry powder inhalers inhaler technique

**Table 3: Completion of pMDI inhaler technique steps performed according to specified characteristics**

| Characteristic | Complete steps *N* (%) | Incomplete steps *N* (%) | Total *N* (%) | $\chi^2$ (*P* value)* |
|---|---|---|---|---|
| Sex | 31 (22.1) | 109 (77.9) | 140 (100) | 0.954 (0.33) |
| Male | 12 (18.5) | 53 (81.5) | 65 | |
| Female | 19 (25.3) | 56 (74.7) | 75 | |
| Educational status | 31 (22.1) | 109 (77.9) | 140 (100.0) | 18.643 (<0.001) |
| No formal education | 0 (0.0) | 4 (100.0) | 4 | |
| Primary | 7 (10.3) | 61 (89.7) | 68 | |
| Secondary | 11 (52.4) | 10 (47.6) | 21 | |
| Tertiary | 13 (27.7) | 34 (72.3) | 47 | |
| Confident in use of inhaler | 31 (21.1) | 109 (77.9) | 140 (100.0) | 0.001 (0.99) |
| Very confident | 25 (22.1) | 88 (77.9) | 113 | |
| Not confident | 6 (22.2) | 21 (77.8) | 27 | |
| Source of instruction | 31 (22.1) | 1.09 (77.9) | 140 (100.0) | 7.938 (0.09) |
| Doctor | 22 (20.8) | 84 (79.2) | 106 | |
| Pharmacist | 0 (0.0) | 7 (100.0) | 7 | |
| Nurse | 5 (33.3) | 10 (66.7) | 15 | |
| Non health-care person | 4 (50.0) | 4 (50.0) | 8 | |
| Literature | 0 (0.0) | 4 (100.0) | 4 | |
| Frequency of symptoms | 31 (22.1) | 109 (77.9) | 140 (100.0) | 9.900 (<0.01) |
| Daily | 0 (0.0) | 24 (100.0) | 24 | |
| Weekly | 12 (34.3) | 23 (65.7) | 35 | |
| Monthly | 19 (23.5) | 62 (76.5) | 81 | |

**P values* were calculated with the use of Pearson's Chi-square test, pMDI: Pressurized metered dose inhaler

**Table 4: Completion of DPI inhaler technique steps performed grouped according to specified characteristics**

| Characteristics | Complete *N* (%) | Incomplete *N* (%) | Total *N* (%) | $\chi^2$ (*P* value) |
|---|---|---|---|---|
| Sex | 19 (37.3) | 32 (62.7) | 51 (100) | 0.844 (0.36) |
| Male | 10 (32.3) | 21 (67.1) | 31 | |
| Female | 9 (457) | 11 (55) | 20 | |
| Education | 19 (37.3) | 32 (62.7) | 51/100 | 0.110 (0.74) |
| Primary | 11 (31.3) | 17 (60.7) | 28 | |
| Post primary | 8 (34.8) | 15 (65.2) | 23 | |
| Confident in use of inhaler | 19 (37.3) | 32 (62.7) | 51 (100) | 4.759 (0.03) |
| Very confident | 18 (45) | 22 (55) | 40 | |
| Not too confident | 1 (9.1) | 10 (90.7) | 11 | |
| Source of instruction | 19 (37.3) | 32 (62.7) | 51 (100) | 10.145 (<0.01) |
| Doctor | 15 (41.7) | 21 (583) | 36 | |
| Nurse | 0 (0) | 10 (100) | 10 | |
| Others | 4 (80) | 1 (20) | 5 | |
| Frequency of symptoms | 19 (77.3) | 32 (62.4) | 51 (100) | 0.412 (0.81) |
| Daily | 2 (33.3) | 4 (67.7) | 16 | |
| Weekly | 455 | 6 (51.5) | 11 | |
| Monthly | 12 (353) | 22 (64.7) | 34 | |

DPI: Dry powder inhaler

**Table 5: Logistic regression analysis showing the association between completion of the steps of inhaler technique and independent variables**

| Variable | *B* | SE | *P* value | OR | 95% CI for OR | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Higher educational status (pMDI) | 1.636 | 0.472 | <0.001 | 5.058 | 2.005 | 12.758 |
| Monthly asthma symptoms (pMDI) | 0.170 | 0.437 | 0.70 | 1.185 | 0.503 | 2.792 |
| Confident in the use of inhaler device (DPI) | 2.025 | 1.102 | 0.07 | 7.578 | 0.874 | 65.715 |
| Inhaler technique taught by a doctor (DPI) | 0.468 | 0.711 | 0.51 | 1.597 | 0.396 | 6.435 |

pMDI: Pressurized metered dose inhaler, DPI: Dry powder inhaler, OR: Odds ratio, CI: Confidence interval, SE: Standard error

whether it is pMDI or DPI. It also showed that significantly more DPI users followed the correct sequence of steps required during inhalation than do pMDI users as documented earlier.[10] It equally showed that patient dependent factors like educational status affected completion of the inhaler technique steps.

Our study showed that only 22.1% of pMDI users and 37.3% of DPI users were able to complete all the steps in their different techniques. About 26.2% of both pMDI and DPI users completed the nine steps without mistakes. In the work by van Beerendonk *et al*. in the Netherlands,[11] only 11.1% patients completed the required steps. Our finding is consistent with that of Adeyeye and Onadeko working in Lagos State University Teaching Hospital, Lagos Nigeria;[12] 32% of the 106 asthmatic patients they studied performed all steps of inhalation technique. The 11.1% recorded by van Beerendonk *et al*. compared to 26.2% in our study may have resulted from studying a population with a higher mean age (61.83 [14.56]) as well as their finding that older patients had more difficulty with the correct use of the inhaler than younger patients. Adeyeye and Onadeko studied patients who were in the age range of 13-64, comparable with our study. However in contrast to our study, a systematic review of other previous studies showed that higher percentages of patients used their inhalers correctly; About 63% for metered dose inhalers (MDIs); 75% for breath-actuated MDIs; and 65% for DPIs.[13] The bulk of the data for that review were outside Africa, where education of patients on inhalation technique could probably have been better.

We found that DPI users made fewer mistakes than pMDI users during inhalation. The type of inhalator device is an important determinant of incorrect inhalation technique with most previous studies showing that DPI users were able to complete the steps better than pMDI users.[3,10] This is probably because pMDI device requires hand-breath co-ordination unlike DPI. One review of inhaler technique on the other hand concluded that there is no difference in the ability of patients to use DPIs or MDIs.[13] However, this finding was noted among patients who were supposedly taught the correct inhaler technique just before their ability to use an inhaler was assessed.

The factors that significantly affected pMDI inhaler technique in this study include education and frequency of asthma symptoms. Fewer percentages of patients with no formal or with primary education completed the steps of inhaler technique than did those with secondary and tertiary education. This is comparable to what was observed in an earlier study where poor inhaler technique was associated with less education.[4] Furthermore none of the patients with

daily asthma symptoms completed the pMDI inhaler steps as compared those with weekly (34.3%) and monthly (23.5%) symptoms ($P$ = 0.007). A previous study has documented higher rates of poor technique in DPI users with severity of airway obstruction.[14] Daily asthma symptoms may well be a consequence of poor inhaler technique since this would result in an ineffective drug delivery. Ineffective drug delivery of asthma medication due to incorrect use of an inhaler device has been associated with an uncontrolled asthma in recent study in Nigeria.[15]

Among DPI users, our study revealed that those who have been taught the use of the technique earlier by a doctor and those who felt that they very confident in their use completed the whole steps more than their counterparts. However, logistic regression analysis of these variables did not show that they were good predictors of completion of DPI inhalation technique.

It is however interesting to note that none of the patients using DPI who received the instructions by nurses could perform the technique correctly and equally those who received the instruction from Pharmacists could not perform the MDI technique correctly. This calls for a lot of concern because usually both nurses and Pharmacist are important health providers required to give instructions relating to inhaler use in well-organized asthma care units. We are of the opinion that these health-care providers should be continuously trained and retrained on the techniques of inhaler use.

Similar to our observation, Gray *et al*.[16] found no association between age, sex and prediction of incorrect pMDI among subjects with a mean age of 69.7 years. In contrast Goodman *et al*.[17] found that males perform significantly better than females in subjects aged 20-81 (mean 38 years). This difference may be related to the sample age range.

The most common errors in the use of pMDI in our study were step 7 (Continue to inhale until the lungs are full), followed by step 6 (Trigger the inhaler while breathing in deeply and slowly). For DPI the most common errors were step 2 (Sit upright or stand) followed by step 4 (Exhale deeply, away from the mouthpiece). These findings are consistent with those of van Beerendonk *et al*.,[11] who identified steps 7 and 4 as the most common "skill" and "non-skill" mistakes respectively. Similarly, other studies identified our steps 7 and 6 as the most common mistake made by patients using an MDI.[3,18,19] Indeed the most important aspect of inhalation technique in pMDI is a slow (<60 L/min) and deep inhalation.[20]

This study however has some limitations; it was not possible to ascertain whether the inhaler technique, which patients had been taught by health practitioners prior to this study, was correct. Hence the impact of previous teaching of inhaler technique to patients was not assessed properly. The assumption that inhaler technique taught by any doctor or other health-care providers must be correct may not be true as studies have shown that health-care providers may not know how to use inhalers correctly.[5,6] This could form basis of future research which will assess the knowledge of the inhaler techniques among health-care practitioners that actually teach the patients how to use the inhalers.

Equally, some other significant determinants of an incorrect inhaler technique were not assessed in this study and include low score in mini mental state examination, poor hand grip strength[17] bronchodilator unresponsiveness, lack of additional teaching on proper inhaler technique, lack of patients perception of importance of inhaler use, low emotional quality-of-life and being treated in a general practice.[18]

Furthermore the small number of subjects studied may have affected some of the conclusions drawn from this study.

In spite of the limitations, this study has been able to assess inhaler techniques among selected asthma patients seen in a developing nation like Nigeria and was carried out in two major regions of the country and will no doubt add to the body of literature in this area of practice.

This study which is the first comprehensive study of this sort in a resource poor country like Nigeria is expected to generate future research in this novel area including assessment of health-care provider knowledge of correct inhaler technique. It will equally form bases of continued education of the patients who use these inhalers during their routine clinic visits.

## Conclusion

Our study showed that majority of our asthma patients used their inhalers inaccurately. Patient-dependent factors were identified as the cause of incorrect technique of inhaler use. There is need for increased awareness among all the health-care personnel involved in asthma care most especially the Pharmacists ensuring they know the correct inhaler technique since most patients from our study were actually taught by doctors on the use of the inhalers.

We recommend that instructions on the use of the inhalers should be translated to several local languages for ease of understanding.

Asthma patients on inhalation medications should have their inhaler technique routinely checked during visits and should be given detailed education on proper inhalation technique if found to be poor.

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