Effectiveness of Software-Based Patient Education on Inhaler Technique: A Clinical Study

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National asthma guidelines to improve asthma outcomes rely on inhaled medications. However, it has been commonly recorded that the majority of asthma patients use inhalers incorrectly and that poor inhaler technique is correlated with poor asthma control. In fact, more than 25% of the 25 billion dollars spent on inhalers annually are misspent on incorrect inhaler use. Common inhaler education is written instruction, but some patients receive no training. We decided to test the effectiveness of a computer based training solution versus traditional written instruction on inhaler technique. An example of a computer based training solution used was videos found at www.use-inhalers.com. The computer based training would be easy to use and implement in clinics, or directly to patients at home. We hypothesize that it can increase a provider’s ability to deliver high quality instruction to all patients without increasing time burden on providers. Our controls were patients without any training and patients given written training. Videotapes of patients using their inhalers before and after training were created and analyzed by a fixed rubric and given a score. 50 patients were recruited in the Junta De Beneficencia Hospital in a randomized, unblinded enrollment process. Analysis was done through multivariate regression analysis where the different trainings were binomial indicator variables. Video training improved inhaler technique by more than 70% (p<.0001), and did not show age preference. Written training had little to no influence on inhaler technique (p>.05), and on average, only improved technique by less than 10%. We conclude that (1) written instruction may not be enough to instruct patients for inhaler technique education (in fact, most patients missed more than 50% of the necessary steps) and (2) a computer-based alternative can have the desired educational effect without an increased time effort.

Background
Asthma affects around 10% of the global population, and one in two of affected patients had an asthmatic attack in 2008. Medical problems associated with respiratory diseases account to several millions annually of lost earnings and medical expenditures (Jurado). National asthma guidelines to improve asthma outcomes rely heavily on the use of inhaled medications and inhalers. However, as many as 86% of patients use the Metered Dose Inhaler (MDI), the most common inhaler, incorrectly and inhaler technique has been shown to deteriorate over time. Numerically, of the $25 billion/year spent on inhalers, about $7 billion are misspent on incorrect use of inhalers.

Al Jalhadi et al (2013) did a cross sectional study measuring the effect of inhaler technique on overall respiratory health. Incorrect inhaler use was correlated with uncontrolled asthma control (ACT<15, p<.001) and 3 or more visits to the ER (p<.05). It also showed that inhaler technique deteriorates over time and without asthma education. Incorrect technique results in more drug deposition to the mouth than to the lungs, which hinders the effectiveness of an inhaled medication. Common issues include problems with hand-breath coordination, failure to fully inhale or exhale, forgetting to tilt the head before inhalation, and other problems that can be corrected with training. Commonly used tools for education on inhaler technique include verbal/written instructions or a quick demonstration by healthcare workers (who may not have received proper training). Unfortunately, some patients may receive no training when healthcare providers are too busy.
This problem is severe in Ecuador, where shortages of medical professionals are severe. Respiratory medical issues are a large problem in Ecuador. Many families are not able to buy fumeless stoves in their homes, fostering long and short term respiratory diseases. Manufacturing plants and motor vehicles which do not pass American clean energy standards emit large amounts of air pollution. Tropical Deforestation effectively destroys the oxygen content of the air. Air pollution and high levels of smoke harm the lungs in patients, similar to damages caused by second hand cigarette smoke. In both children and adults, this destruction creates an epidemic of asthma and respiratory illnesses. Online tools and videos have proliferated but are mostly passive and lack important attributes such as ease of use, accessibility and comprehensiveness. High rates of improper inhaler techniques in recent studies show that we need tools that are more effective and reduce time demands on busy practitioners. A training which provides patient education with more effectiveness at a lower cost without additional time effort is sorely needed.

A computer based inhaler training solution could be a possible solution. Potential benefits include education for all inhaler devices (more than 15 inhalers in use today across several brands) that are easy to use and able to be implemented in a clinic easily. It could increase a practice’s ability to deliver high quality instruction to all patients without increasing time burden on providers. Software products would use simulation technology which include interactivity and animations to engage patients, increasing confidence inhaler use and knowledge retention. In essence, the interactivity can teach correct inhaler more effectively than written training, and possibly as well as training directly from a provider. Nevertheless, solely the widespread nature of computer based training would increase in the number of patients getting detailed training. The ability of patients to use the training more than once from any location at any time could correct incorrect inhaler technique, and accordingly, improve asthma outcomes.

Methods
Study Design
A prospective, randomized, unblinded enrolling of 50 patients at the Luis Vernaza Hospital in Guayaquil, Ecuador. Other patients will be recruited from other hospitals in the NGO Junta De Beneficencia network of hospitals. Inclusion criteria included clinically-stable outpatient patients (≥8 years) with asthma or COPD with history of at least one exacerbation in last 1 year, (ii). Clinical diagnoses of asthma or COPD, while exclusion criteria included (i). Patients with language barrier (unable to understand and communicate in either English or Spanish), (ii). cognitive or physical dysfunction that, in the investigator’s opinion, would interfere with completion of the study, (iii) significant co-morbidity that can confound asthma symptoms — e.g. CHF, current smoker, uncontrolled GERD, neuromuscular disease, chest wall deformity.

Study Procedures
At hospital discharge, eligible subjects were approached to participate by doctors. In addition, members of the Asthma Club of Guayaquil were encouraged to come participate. Each patient conducted an interviewer-led ACT (Asthma Control Test). The test judges general asthma control; it asks questions dealing with shortness of breath, ER visits, inhaler use, and inhaler effectiveness. It is graded out of 25 points per patient. Phone numbers as well as age was collected.

Individuals participating in the study were video recorded using their inhaler from their current knowledge. A control group was given Spanish written training (the extent of normal training for patients in Ecuador) for inhaler training, and re-filmed for technique improvement.

A test group was given a Spanish computer based inhaler training, and video recorded using their inhaler after training. The video based training is located at the website www.use-inhalers.com. It incorporates simple videos of healthcare professionals using their inhalers, and uses the webcam to create a mirror for the patients who can practice their inhalers along with videos. In addition, animations provide an internal view of the inner working and reasons for using an inhaler. Interactive courses like this are available online, and can be included in a clinic simply with a computer. After training, the test group was again video recorded to record improvement.

Videos were graded on a variety of criteria. Users were given points for taking off the inhaler cap, shaking the inhaler before use, proper posture and
head position, proper grip, exhalation, and inhalation upon inhaler activation, release of medication, and holding their breath. They were graded on an 11 point rubric. They would receive up to points for doing each step correctly for up to 11 points. The steps and criteria for correct inhaler technique coincide with international standards on inhaler use and common problems that are encountered for Metered Dose Inhalers11.

Statistical Analyses

Simple correlation testing was done between variables. Multivariate linear regression was conducted, between inhaler technique before and after no, written, and video training. We studied the effect that the different training types had on our rubric for inhaler technique score. A numerical improvement (one step done correctly while all the other steps remained the same) on the rubric resulted in a 1/11 ~ 10% improvement in inhaler technique. Age and ACT score were used as variables in the regression to dissuade possible bias; however, these variables were not correlated with changes in improvement or inhaler technique.

As we had 50 patients, we could assume normal distribution. A two-tailed p value of less than .05 defined statistical significance. Computations were done using STATA version 12.

Results

The study population consisted of 50 patients who took videos of themselves using their inhalers 2 times, giving us 100 videos to work with.

Table 1 shows the base data that we obtained from our study – it shows the averages for age and ACT score (a representation of respiratory health) for each group, as well as on average, their inhaler technique before and after training. Our initial analysis shows that video training is positively correlated with improved inhaler technique, while written training does not seem to be correlated with improved training. It is also important to note that neither age nor act score was very different between the two groups so both groups seemed to start off in similar circumstances.

| TABLE I |
|--------------|---------------|---------------|
| | No Training | Written Training | Video Training |
| Age | 48.22 (18.08) | 47.3 (16.70) | 48.3 (18.92) |
| ACT Score | 14.5 (3.23) | 14.7 (2.59) | 14.36 (3.60) |
| Training Score Before | 5.19 (2.50) | 5.7 (2.75) | 4.73 (2.23) |
| Training Score After | ----------- | 6.23 (2.68) | 7.93 (2.30) |
| Correlation with improvement in training | ----------- | -0.1390 | 0.7195 |
| n (number of participants) | 100 | 20 | 30 |

For our analysis, we used 3 test variables, and included others in our regression to see effect that age and current respiratory health would have on change in inhaler technique. Our main dependent variable was inhtheqdiff, which represented the change in inhaler technique before and after training (either written or video). This was measured in the point on the 11 point rubric; thus, if patients did one step correctly that they had not done before, while doing all other steps the same, their value for inhtheqdiff would be 1. Therefore, inhtheqdiff is a variable that is a proxy for improvement in inhaler technique.

We incorporated written treatment and video/online treatment as indicator variables represented by wrtreatment and vidtreatment, respectively. Multivariate regression analysis was run with the dependent variable inhtheqdiff and the dependent variables represented by the indicator variables wrtreatment and vid treatment. Additional
regressions were run with Age and ACT score included as variables to dissuade bias. Figures 1 show the results that we actually obtained directly from STATA. Table 2 shows a summary of this data for each regression.

**FIGURE I**

**REGRESSIONS TRAINING/TREATMENT VS. INHTEQDIFF**

| inhteqdiff     | Coef.  | Std. Err. | t     | P>|t|   | [95% Conf. Interval] |
|----------------|--------|-----------|-------|-------|---------------------|
| wrtreatment    | .525   | .2721502  | 1.93  | 0.057 | -.0151428 - 1.065143 |
| vidtreatment   | 3.2    | .413545   | 7.74  | 0.000 | 2.379228 - 4.020772  |
| _cons          | 2.22e-16 | .        | .     | .     | .                   |

Linear regression  
Number of obs =  100  
F( 2, 97) = 31.80  
Prob > F = 0.0000  
R-squared = 0.5282  
Root MSE = 1.3548

| inhteqdiff     | Coef.  | Std. Err. | t     | P>|t|   | [95% Conf. Interval] |
|----------------|--------|-----------|-------|-------|---------------------|
| wrtreatment    | .5226871 | .2704361 | 1.93  | 0.056 | -.0141244 - 1.059499 |
| vidtreatment   | 3.201542 | .4149264 | 7.72  | 0.000 | 2.37792 - 4.025164   |
| age            | -.002514 | .0083096 | -0.30 | 0.763 | -.0190084 - .0139804 |
| _cons          | .1212253 | .4007324 | 0.30  | 0.763 | -.6742222 - .9166728 |

Linear regression  
Number of obs =  100  
F( 3, 96) = 21.76  
Prob > F = 0.0000  
R-squared = 0.5287  
Root MSE = 1.361
The binomial indicator variables demonstrate the effect of the interactive online training on inhaler technique vs. no training and written training. Video training improved inhaler technique by 3.20 points on the rubric. As the initial score on the rubric for these individuals was around 4.73, it seemed that the video training had improved inhaler technique by 3.20 point on the rubric on average. Therefore, it improves inhaler technique by 3.20/4.73 ~ 70%. In addition, this information is statistically significant (p<.0001, confidence interval of [2.27, 4.02]).

Written training, on the other hand did not have such a statistically significant effect. Written instruction only improved inhaler training on an average of .525 points.
points, and thus improved technique on average by 0.525/5.19 ~ 10%. However, it is not statistically significant (p>.05), and the 95% confidence interval includes 0, meaning that written training may or may not have an effect on inhaler technique.

In addition, Age and ACT score were included as additional variables in the multivariate regression (Figure 1b and 1c). We wanted to see if the video training was the real factor in improving technique, and it was not due to different changes in age or respiratory health (represented by ACT score). When these variables were included, the regressions and beta values on wttreatment and vttreatment changed negligibly. In addition, improvement in inhaler technique was uncorrelated (|correlation|<.01) with inhaler technique improvement.

**Discussion**

Inhaler technique and proper use time and time again has been shown to help improve asthma and COPD outcomes. An industry as large as inhalers commands more investment into fixing problems with its use. In this study, patients who should have been using inhalers or have been diagnosed inhalers, missed 6/11 important steps in using an inhaler. This corresponds and enforces the point that no education in inhaler training should not be an option. Without any training, patients will incorrectly use inhalers their entire lives, which will lead to more ER visits, problems with asthma control, and discomfort. Interactive audiovisual programs may be a potential solution.

The interactive training was shown to improve inhaler technique by 70% on average. This correlates to patient’s recalling 3 or 4 important steps in using their inhaler that they previously would not have known about or remembered. Certain steps that were taught well by the program (that trained individuals remembered that others did not) include exhaling fully before inhaling, holding breath with medication in lungs, and sitting with right posture when using the medication. Interactive training leads to better retention of information. Patients who took the course will now able to remember to complete 3 or 4 more steps each time they use their inhaler. As studies have shown in Al Jalhadi et al (2013), the improvement in inhaler technique will lead to improved asthma control and respiratory health.

On the other hand, written training was not conclusive. As the data was not statistically significant, we cannot make any conclusions. However, on average, it did not teach patients any steps that they did not already know. Written instruction may not be sufficient to teach patients how to use their inhalers. It is important to note that the study may have not correctly estimated the effect of written treatment. Patients who were apart of the study may have already had the written training, and thus have had already learn as much as they could from written training. Thus, they may have been learning the same things again in the written training, and the written training given would not accurately depict how much a patient can learn from written training. Video training, however, was shown to improve on this written training if in fact this is true.

The plausibility of such an interactive resource is also important to discuss. Such a resource not only can improve inhaler technique in the short term as shown in this study, but increases long term retention as it is an interactive resource, and can be accessible from anywhere at any time. The proliferation of such a material would be very easy. It is accessible on smart phones and tablets, and any patient could use it at any time for a refresher or while they are using the medication. Most importantly, it does not require additional help from health providers. In developing countries like Ecuador, it is a must. Several of the patients in the study conducted were unable to read, and therefore, did not absorb anything from the written instruction. Interactive and video training would be even more important in similar situations. Globally, this type of training is easy to spread, easy to use, and could be effective.

In developed countries like the United States, almost 86% of individuals also use inhalers incorrectly. In reality, asthma patients in the U.S. have the same problems with inhaler technique that those in Ecuador too. However, results could be different in developed countries. It is important to note that patients in developed countries may be able to absorb the written training better than developing countries. However, it is hard to discount the positive effect that audiovisual training can have. It is also important to note that retention was not measured in this study, and whether individuals will retain their training is debatable. However, studies do show that students learn the most when they are interacting with their
education, and when they can hear or see what they are learning rather than just reading it. Nevertheless, in a developing countries like United States, the abundance of smart phones and tablets make the program even more accessible. As many trainings like this one are available in many languages (Use-Inhalers, the technology used in this study, is available in English, French, Spanish, and Hindi), they can be used across the world from anything with an internet connection.

In conclusion, audio visual interactive training can improve inhaler technique, which studies show serve as a proxy for asthma control. Written training may not be enough to teach patient’s effectively about how to use their inhaler. Currently, most patients in both developed and developing countries do not use inhalers correctly. A change is needed. Audiovisual training which incorporates animations and videos seem to be a possible solution that does not increase time burden of a provider.

References
10. Yildiz, F. Importance of inhaler device use status in the control of asthma in adults: ASIT Study. Respiratory Care. 2013 July