

19 LUNG FUNCTION USING NDD EASY ON-PC

19.1 Introduction

Lung function tests objectively assess respiratory function and are widely used in clinical practice to diagnose and monitor the progress of respiratory diseases such as asthma and chronic obstructive pulmonary disease (COPD). A lung function test produces values across the various measures tabled below (Table 1). A wide range of variables can affect these factors, for example smoking, chronic bronchitis, poorly controlled asthma, some muscular disorders and many other conditions. Results also vary according to a respondent's age, sex, height and ethnicity. At a population level, these measures tell us a lot about the respiratory health of the population and can be used to monitor trends in the prevalence of respiratory disease over time.

For an adult, a spirometry manoeuvre (a 'blow') is deemed technically acceptable if the respondent completes it with the correct technique and the blow is as rapid as possible and lasts until the lungs are empty. In COPD, this may take 15 seconds or longer. A spirometry test, comprising of all of the respondent's manoeuvres taken together, is deemed technically acceptable if they have a minimum of three acceptable manoeuvres of which two are reproducible.

Table 1 Lung function test values

Test	Abbrev	Definition
Forced Vital Capacity	FVC	The total volume of air that can forcibly be blown out after a full inspiration, measured in litres.
Forced Expiratory Volume in 1 Second	FEV ₁	The volume of air that can be blown out in one second, measured in litres during a forced manoeuvre
FEV1%	FEV ₁ /FVC	The ratio (%) of FEV ₁ to FVC.
Peak Expiratory Flow	PEF	The speed of air moving out of the lungs at the beginning of expiration, measured in litres per second.
Forced Expiratory Flow	FEF(25-75)	The average flow (or speed) of air coming out of the lungs during the middle portion of expiration, measured in litres per second
Forced Inspiratory Flow	FIF	Similar to FEF except the measurement is taken during inspiration.
Forced Expiratory Time	FET	The length of expiration in seconds.
Tidal Volume	V _T	The specific volume of air that is drawn into the lungs and then expired during a normal respiratory cycle.

19.2 Exclusion criteria

Respondents are excluded from the lung function measurement if they:

- Are pregnant
- Have had abdominal or chest surgery in the last three months
- Have had a heart attack in the last three months
- Have detached retina or eye surgery or ear surgery in the past 3 months
- Have been admitted to hospital with a heart complaint in the preceding month
- A resting pulse rate more than 120 beats/minute (respondent should be sitting for at least 5 minutes prior to the pulse rate being taken)
- Are currently taking medications for the treatment of tuberculosis

As with all measurements and samples, a respondent is excluded from the lung function measurement if the nurse deems it unsafe for them to continue. This may be due to concerns over the respondent's understanding of the measurement or concern over infection control if they have a cough or chest infection.

19.3 Equipment

You will need:

- An NDD Easy On-PC spirometer
- A 3 litre calibration syringe
- Spirettes
- Chair (preferably with arms)
- Nose clip

19.3.1 The NDD EasyOn PC spirometer

The NDD EasyOn-PC spirometer is different from any spirometer used by NatCen in the past as it plugs into the laptop. This allows for the respondent's results to be obtained automatically by the spirometry program which has been installed on the laptop. Therefore the respondent's results do not need to be manually entered into the CAPI.

Additionally, the spirometry program will give you the overall session quality as a grade (see section 19.8 for further information) and tell you when a respondent has done sufficient manoeuvres for the overall test to be acceptable.

If a respondent is struggling with the lung function manoeuvre, the spirometry program will give you the instructions you need to tell the respondent to help them give successful and valid blows.

19.3.2 Caring for the spirometer

The spirometer needs minimal care and maintenance. There are no moving parts which need to be cleaned at regular intervals. Please do not attempt to take the housing apart to clean it, this is not necessary and will result in the spirometer being

damaged. Proper use of the spirette with the spirometer will ensure the interior of the spirometer remains clean.

It is important that the external housing is wiped over before it is used by a respondent. This will remove any dust and fingerprints from the plastic casing. This should be done using an anti-bacterial wipe. The inner tube of the spirometer which contains the sensor does not need to be cleaned as the spirette ensures that this remains uncontaminated. Tests done by the manufacturer show that the spirette prevents 99.9% of germs from being in contact with the inner tube of the spirometer.

It is important that you wipe the external plastic casing between respondents within a household.

At no time should the spirometer or the attached cord be immersed in water. If this happens, please report it to the operations team who will need to return the spirometer to the manufacturer to be checked.

Please store the spirometer in the plastic zip lock pouch that is provided. This will ensure it remains free of any dust and dirt and will help to keep it protected. This bag should be washed in a warm soapy solution, rinsed and left to air dry as necessary.

19.3.3 Caring for the calibration syringe

The calibration syringe is a very fragile and sensitive piece of equipment. When you receive it, it will be calibrated to 3L. Any knocks, even small ones, to the calibration syringe may cause it to no longer be accurate, making the results of any calibration checks unreliable. For this reason you must not drop or knock the syringe. Please store it in a safe location away from direct heat.

The syringe will need a calibration check every 12 months. You will be notified of when this is required. If you feel the syringe needs checking prior to this, for example it has been dropped, please contact Brentwood who will advise you on what to do.

19.3.4 Calibration/accuracy test

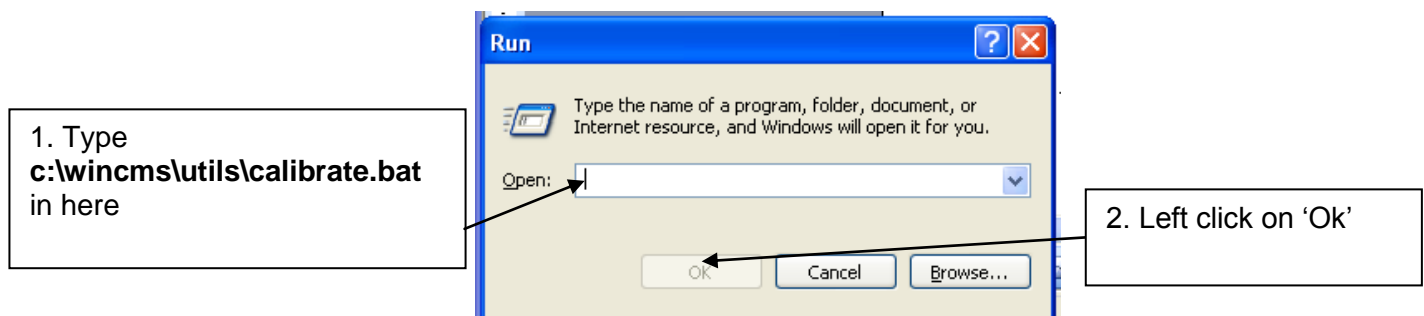
1. Before using the spirometer, its accuracy must be checked by conducting a calibration test. This procedure should be done **in your own home** at the start of each day when you are working. If you have more than one visit in the same day you need to calibrate the spirometer **only once**. You must not take the calibration syringe with you when you make a visit.
2. The calibration check is done using the spirometry software so you will need to turn on your laptop.
3. Connect the spirometer to the laptop using the USB port (see section 19.3.5).
4. Insert a spirette into the spirometer (it is a good idea to keep a spirette with your calibration syringe so that you always have one available). Connect the mouthpiece of the spirette to the adaptor on the end of the calibration syringe as shown below. Ensure the piston is fully inserted and at the stop position.



5. Once your laptop is at the CMS screen hold down the Windows key (shown below) and at the same time press the 'R' key.

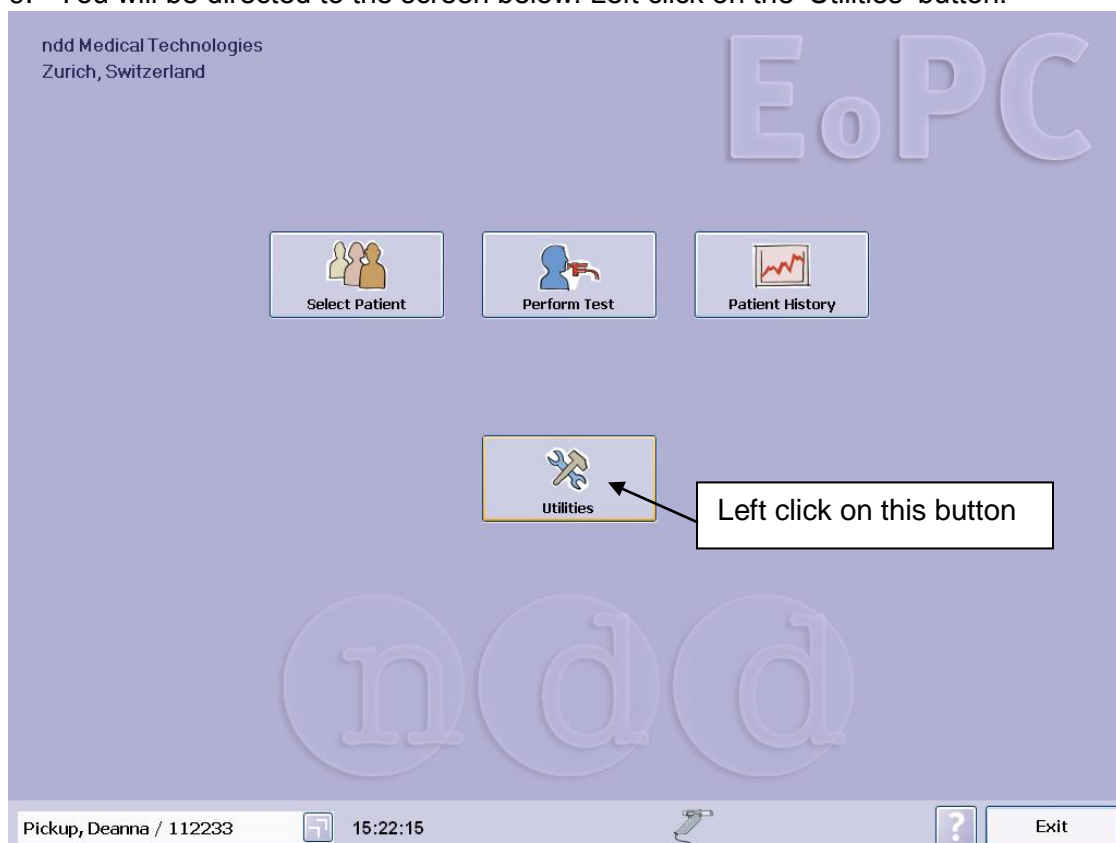


6. You should now have a pop up box in the bottom left hand corner of your screen which looks like this

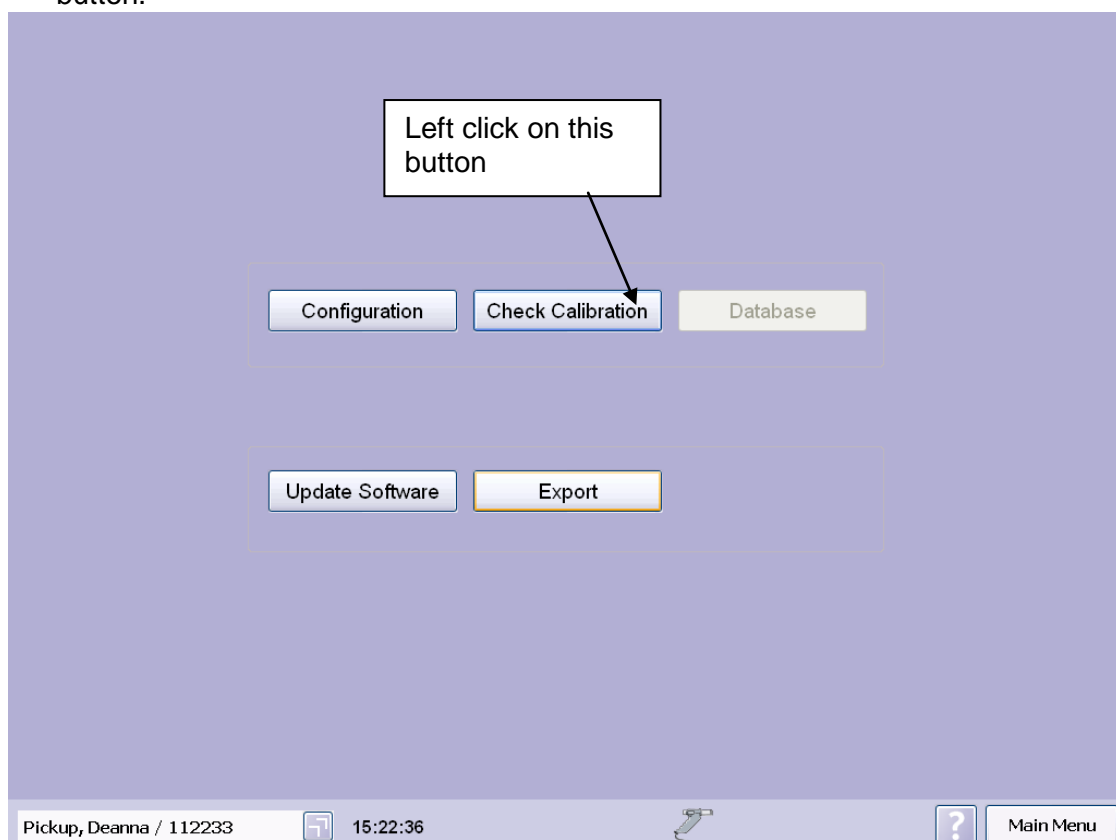


7. In the white box type the link **c:\wincms\utils\calibrate.bat**. You should only have to do this the first time you calibrate the syringe. After this, when you begin to type the link into the box, the laptop should remember it and it will appear in the box without you having to type the whole link in.
8. Once the link has been typed in, left click on the 'Ok' button.

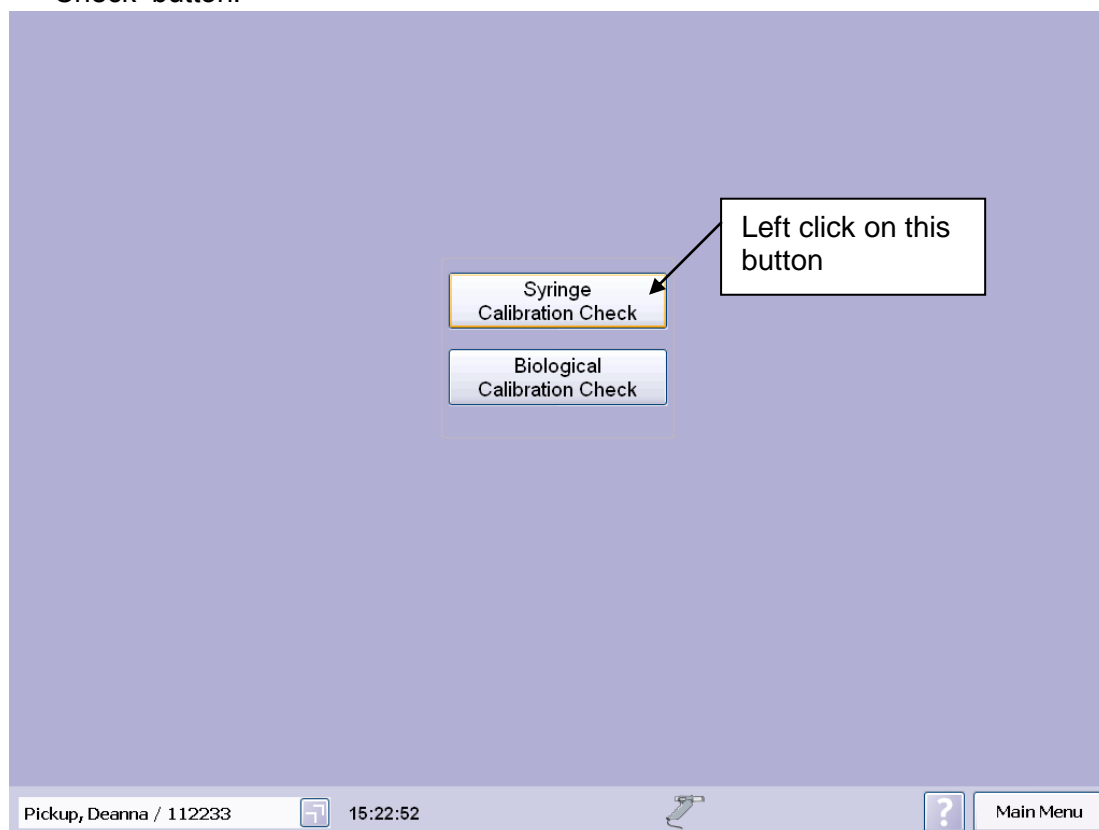
9. You will be directed to the screen below. Left click on the 'Utilities' button.



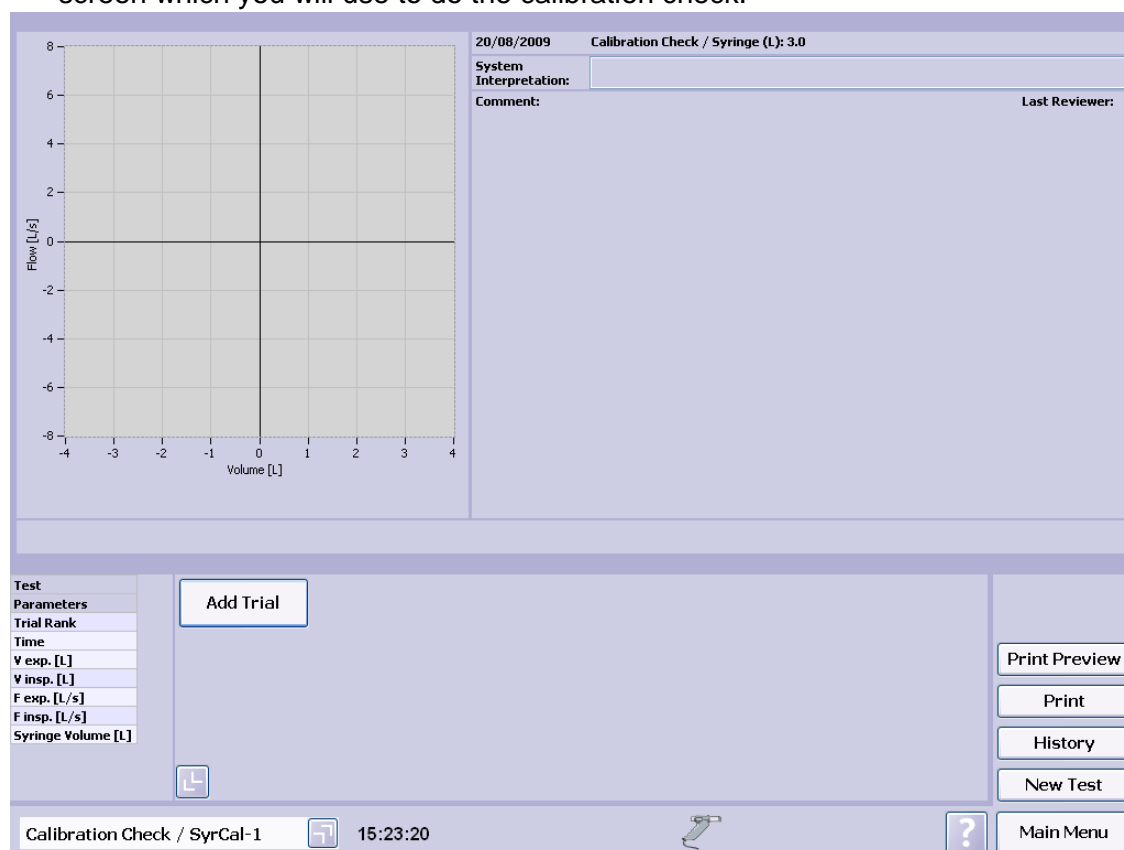
10. You will be directed to the screen below. Left click on the 'Check Calibration' button.



11. You will be directed to the screen below, left click on the 'Syringe Calibration Check' button.



12. You will be directed to the calibration testing screen shown below. This is the screen which you will use to do the calibration check.



13. Left click on 'Add Trial' and wait for the baseline to be set. When you are instructed, with a smooth and steady motion, fully withdraw the piston (a full inspiratory pump) followed by fully pushing the piston in (a full expiratory pump).
14. You will need to do this manoeuvre; a full withdrawal followed by fully pushing the piston in three times, as instructed by the laptop.
15. After you have performed three manoeuvres you should see 'Accuracy confirmed' on the screen.
16. After calibration, left click on 'Main menu'. You will be directed to the 'Utilities' screen, left click on 'Main menu'. This will direct you to the Main menu. Left click on 'Exit'. You will need to confirm that you wish to exit the software by left clicking on 'Ok'.
17. The spirometry software should now be closed and the CMS should be on the screen.

If the spirometer fails the calibration test, please contact Brentwood. Unlike other spirometers, the NDD Easy On PC spirometer cannot be recalibrated. Brentwood will advise you on what to do.

19.3.5 Attaching the spirometer to the laptop

1. The spirometer does not require any batteries. It plugs into one of the USB ports located on the base of your laptop and is powered by this.
2. To attach the spirometer to the laptop, plug the USB adaptor at the end of the spirometer cord into a USB port on the laptop. The USB adaptor and USB port have been colour coded with labels to make this easier, and you should have the coloured dot facing upwards as you plug the adaptor in.
3. If the USB adaptor does not fit easily into the port, (turn the adaptor over and try to insert it into the port again) check that the coloured dot is upward. **Do not force** the USB adaptor into the USB port as this may result in either of them being damaged.

- The spirometer has been connected to the laptop correctly when a small spirometer icon is displayed at the bottom of the computer screen (see below).

General

Patient ID 12345 *

Last Name Pickup

First Name Deanna

Gender Female * Ethnic Caucasian *

Date Of Birth 04 / 11 / 1983 dd/mm/yyyy * Smoker No *

Age 25

Height 168 cm *

Weight 73 kg

* Required

Cancel

Ok

12:44:53

Menu

19.3.6 Assembling the spirometer for use

- Tear open the plastic bag containing the spirette and fold the bag back allowing you to insert the spirette into the spirometer. Ensure that the plastic bag protects the mouthpiece of the spirette until you hand the spirometer to the respondent. This ensures the mouthpiece of the spirette is hygienic and has not been contaminated before you hand it to the respondent.
- To insert the spirette into the spirometer, slide the cylindrical end of the spirette into the hollow of the spirometer. There is only one way that the spirette can be correctly locked into the spirometer, this is done by ensuring the arrow on the top of the spirette is aligned with the arrow on the top of the spirette (see the picture below). The spirette is securely attached when these lock into each other and the spirette cannot rotate inside the spirometer.
- The spirometer is now ready for use.



19.4 Preparing the respondent

Before commencing the spirometry procedure explain the following to all eligible respondents:

- The purpose of the test and how to use the spirometer.
- To ensure an accurate reading they must 'blow' as hard as they can for as long as they can, so long as it does not cause them any pain and/or discomfort.
- The definition of an acceptable level of lung function depends on the person's age, sex, height and ethnicity.
- The number of blows they may have to do and what they need to do for the test to be acceptable i.e. three acceptable blows, of which two are reproducible

The CAPI will prompt you to give this information.

Also ensure that you have a drink of water ready for the respondent.

19.5 Demonstrating

For an accurate reading of lung function it is very important that you demonstrate the blowing technique to each respondent. Do this using a spare spirette that is not connected to the spirometer and follow the procedure below:

1. Explain that the mouthpiece should be held in place by the lips, not the teeth and that the lips are wrapped firmly around the mouthpiece so no air can escape. Explain that the tongue needs to be depressed so that it is not blocking the flow of air into the spirette.
2. Demonstrate a blow, pointing out afterwards the need for full inspiration, a vigorous start to exhalation and sustained expiration. The blow should ideally last at least 6 seconds in duration, if this is possible and not interrupted by coughing, glottis closure laughing or leakage of air. The torso should remain in an upright position throughout the blow, not hunched over.

19.6 Procedure

1. The respondent must be sitting in a chair (this will preferably be a chair with arms and no wheels) with their feet flat on the floor, seated in an upright position. They should loosen tight clothing (for example ties and belts) to allow for a bigger inspiration. If the respondent wears dentures, it is preferable that they leave them in as they will get a tighter seal with their mouth around the mouthpiece which will result in a more accurate result. If the dentures are loose, they can remove them to perform the test.
2. Demonstrate the blow to the respondent (see section 19.5), CAPI will direct you when to do this.
3. Connect the spirometer to the laptop (see section 19.3.5). Insert a spirette into the spirometer ensuring that the plastic bag stays on the mouthpiece of the spirette (see section 19.3.6).
4. Give the spirometer to the respondent, ask them to remove the plastic bag and put the mouthpiece in their mouth. Also give the respondent a nose clip to put on. Instruct them to breathe normally through the spirette while wearing the nose clip.

They should not do a blow at this stage; however it is important that the respondent becomes comfortable with having the mouthpiece in their mouth and the nose clip on.

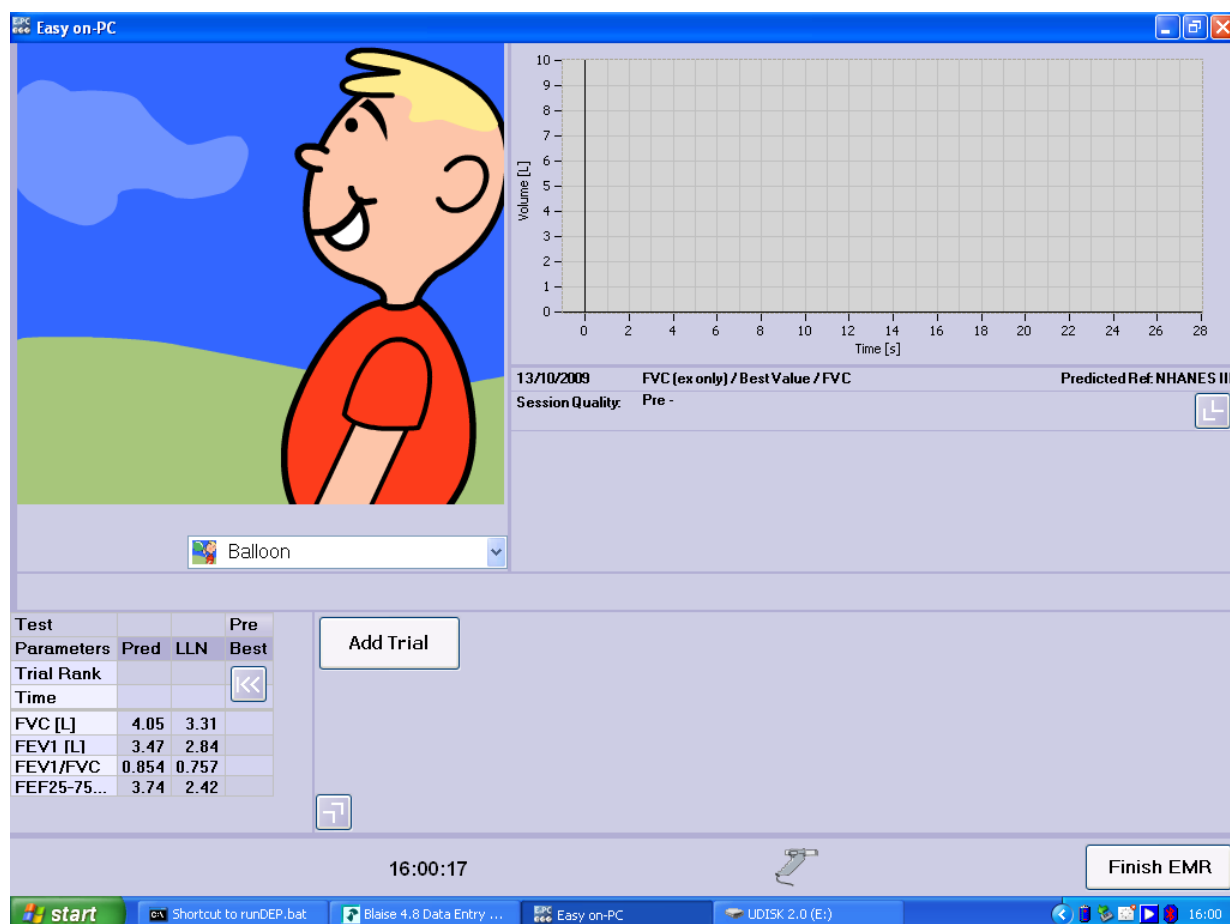
5. When the respondent is comfortable with the equipment, ask them to remove the spirette from their mouth and give the spirometer back to you. Make sure you do not touch the spirette and only hold the spirometer by the handle. They can also remove the nose clip at this point.
6. Start the NDD Spirometry computer program as instructed by the CAPI.
7. Below is the first screen you should see. Check the respondent's serial number (Patient ID), their First Name and their Date of Birth are correct. The fields for height, weight, ethnic and smoker should be pre filled with information from the nurse link. Without this information you will not be able to do a lung function test with the respondent. If the respondent refused their height or weight to be measured at time of interview, CAPI will assume an average value.
8. Also check the spirometer symbol at the bottom of the screen is visible as this means that the spirometer has been correctly connected to the laptop and it is ready to receive information from the respondent blows. When you are satisfied the information is correct, left click on 'Ok'.

The screenshot displays the 'General' tab of the NDD Spirometry computer program. The form contains the following fields and values:

- Patient ID: 12345 *
- Last Name: Pickup
- First Name: Deanna
- Gender: Female *
- Ethnic: Caucasian *
- Date Of Birth: 04 / 11 / 1983 dd/mm/yyyy *
- Smoker: No *
- Age: 25
- Height: 168 cm *
- Weight: 73 kg

At the bottom right of the form, there are 'Cancel' and 'Ok' buttons. A red circle at the bottom center of the screen highlights a spirometer symbol. A text box with an arrow pointing to the 'Ok' button contains the text 'Left click on Ok'. The bottom status bar shows the time '12:44:53' and a 'Menu' button.

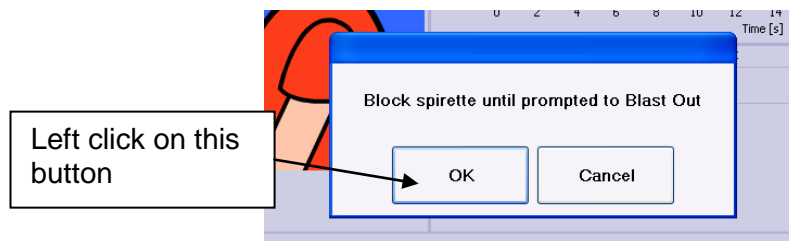
9. You will be directed to the screen below, this is the test screen.



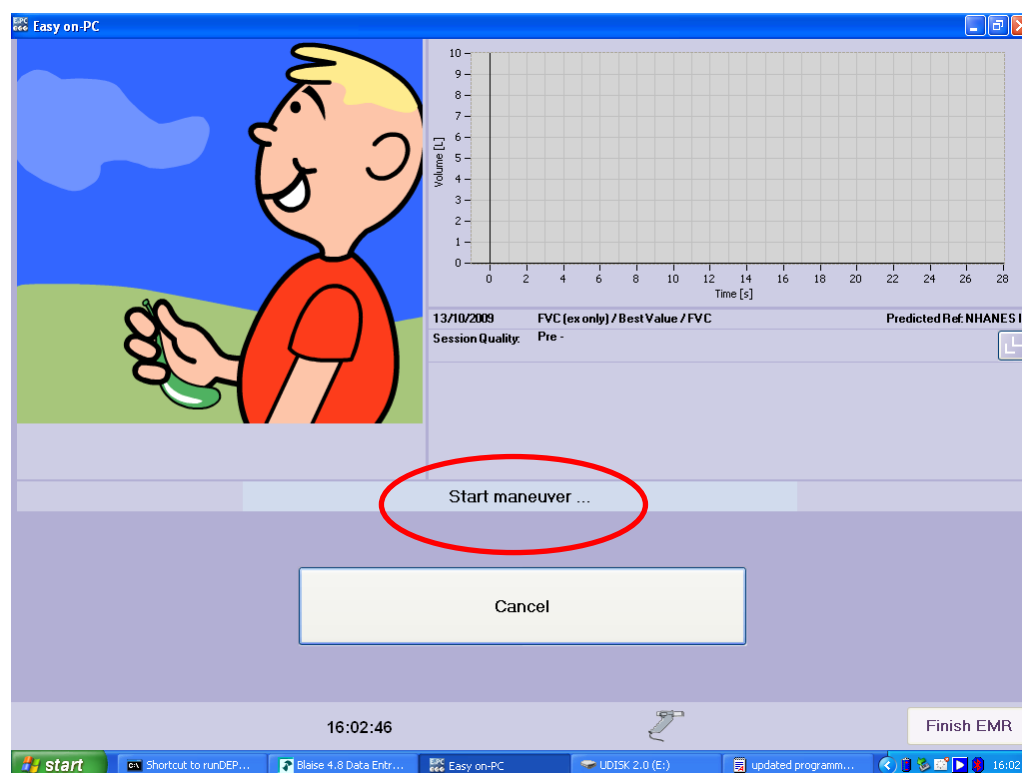
10. Show the screen to the respondent. Explain to them, that in a moment they will need to put the nose clip on and you will click on the 'Add Trial' button which will start the test. Further explain that you will give them the spirometer and they will need to breathe in as deeply as possible and quickly put the spirometer it in their mouth, ensuring a good seal with their lips and then blast out the air with as much force as possible without any hesitation, and to keep breathing out for as long as possible. When they have finished breathing out, they need to take another deep breath in. They can then remove the spirometer from their mouth. Explain that it is a quick process and that while they are doing it the boy on the screen will be blowing up a balloon to encourage them to keep blowing out for as long as they can.

11. Before you give the spirometer to the respondent for the first blow you need to set the baseline. This will need to be done once per respondent. While you are setting the baseline ask the respondent to put the nose clip on, ready to do the blow as the setting of the baseline only takes seconds.

- a. Left click on the 'Add Trial' button, the spirometer will power on. A pop up box will appear on the screen that looks like this:



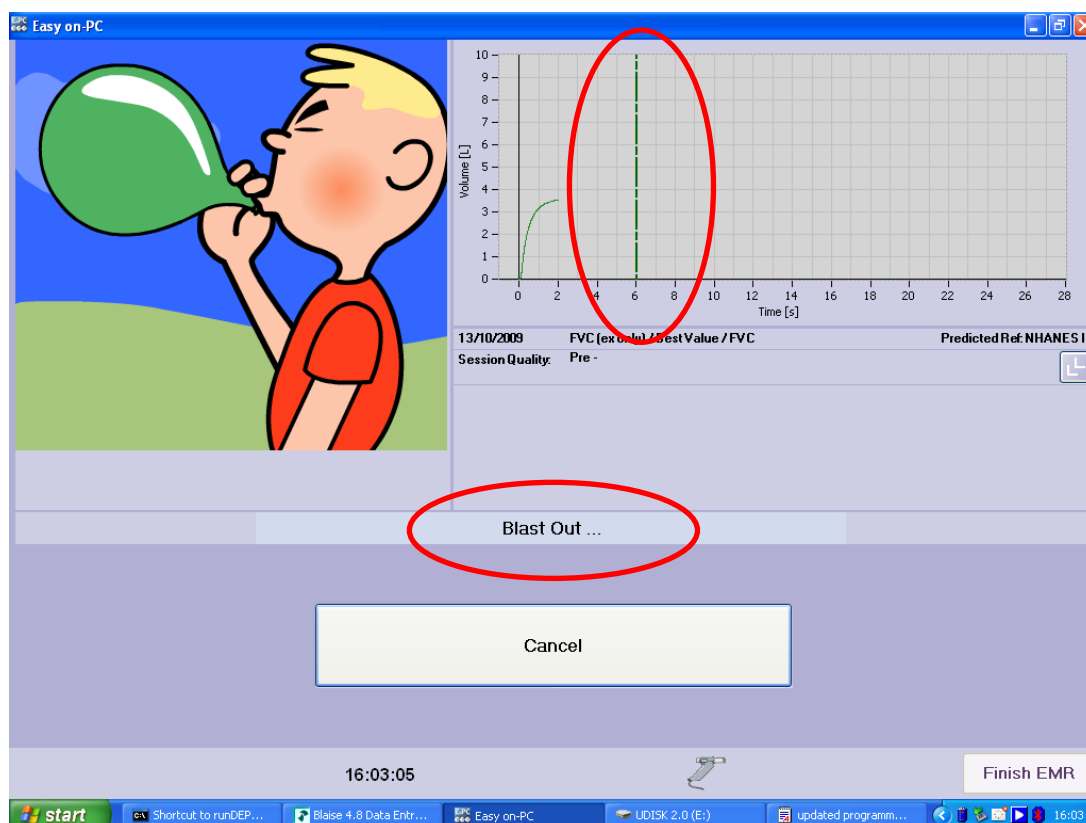
- b. Left click on 'Ok'.
- c. A message will appear above the 'Add Trial' button which reads: 'Setting baseline: Avoid Flow!'. Place your hand over the end of the spirette that the respondent does not use as the mouthpiece. Alternatively, hold the spirometer very still so that no air flows through the spirometer
- d. The baseline is now set and the program will automatically ask you to start the manoeuvre (see below).



10. Immediately hand the spirometer to the respondent and instruct them to breathe in as deeply as possible and then put the spirette in their mouth, ensuring that they make a seal with their lips. The respondent should be able to see the laptop screen so that they can see the animation of the boy. They will need to breathe in and put the spirette in their mouth quite quickly otherwise the program will register it as an aborted test. If this happens, left click on the 'Add Trial', and when the screen reads 'Start manoeuvre' ask them to take a deep breath in ready

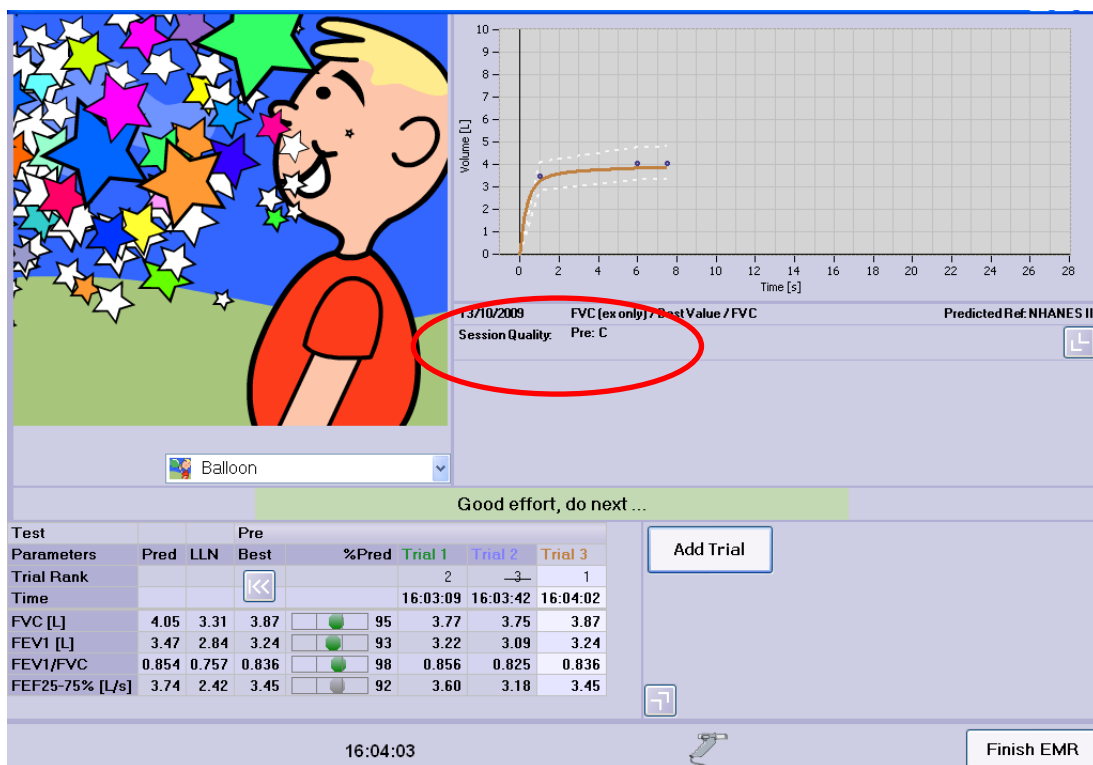
to do the blow. You will not need to reset the baseline, it only needs to be set once.

11. As soon as you can see that they have taken a deep breath in and the spirette is in their mouth, say “blast!”, (the program will also read ‘Blast out!’, see below). As the respondent is blowing encourage him/her by saying “keep going, keep going, keep going...” to get the maximum and fastest expiration possible. Ensure the respondent remains seated upright while blowing. They should also be watching the balloon being blown up on the screen.
12. As soon as they blast out, the 6 second line will appear on the chart (circled below) to tell you for how much longer the respondent needs to blow to meet the criteria for the test to be acceptable; however the respondent should continue to blow out for as long as they can. DO NOT stop them just because they reach the 6 second line on the chart. Keep encouraging the respondent while they are blowing.



13. When the respondent cannot breathe out any more, instruct them to take a deep breath in.

14. When the blow is complete, the program will deem it as either acceptable or unacceptable. If a blow is acceptable, the respondent will see the screen below. If the blow is not acceptable, the program will give you advice on the instruction you need to give the respondent so that their next blow is acceptable (see section 19.9 for a list of these and how to interpret them).



15. Inform the respondent you are going to ask them to do it again, making sure to remind them of any instructions if their test was unacceptable. Also remind them that when you tell them to take a deep breath in and then blast it out, and to keep blowing out for as long as they can. There should be approximately 30 seconds between each blow or longer if required. Allow the respondent to have a drink of water while they rest.
16. Left click on the 'Add Trial' button to start a new manoeuvre. It will first read 'Please wait'. When the screen reads 'Start manoeuvre', ask the respondent to put the nose clip on and breathe in as deeply as possible.
17. Ensuring the respondent can see the laptop screen, ask the respondent to put the spirometer in their mouth. Repeat steps 11-17 until you have reached a session quality of A or B or one of the other stopping criteria is met (see section 19.7). Most respondents should be able to manage what is required but there may be some that cannot. You must strike a balance between encouragement and over-insistence.
18. The program will inform you of the session quality for the respondent, see the screen above. To exit the spirometry program, left click on the 'Finish EMR' button to return to the CAPI.

19.7 Stopping criteria

Respondents should stop the lung function test if any of the following criteria are met:

- The overall session quality achieved is A or B. If a B grade is achieved within a minimal number of manoeuvres and you think the respondent is capable of achieving an A grade by doing more blows, ask them to have another go.
- The respondent has done 8 manoeuvres (blows)
- They no longer wish to continue
- You have concerns for the respondent's safety

If you stop a respondent from doing any further manoeuvres out of concerns for their safety, explain to the respondent that you have all the information that you need and that you will be moving on to the next section.

If you do need to stop a respondent early, left click on the 'Finish EMR' button in the bottom right hand corner of the screen. This will take you back to the CAPI where you will be able to comment why the respondent was stopped early.

19.8 Session quality

Each testing session is assigned a grade which denotes the session quality. This grade is based on the number of acceptable blows and the reproducibility of these. You should aim to get a Grade A or a Grade B with each respondent. This will not always be possible and the stopping criteria in section 19.7 should always be adhered to.

Grade A Three acceptable manoeuvres; two highest FVC and FEV1 within 100ml

Grade B Three acceptable manoeuvres; two highest FVC and FEV1 within 150ml

Grade C Two or three acceptable manoeuvres reproducible within 150-200ml

Grade D One acceptable manoeuvre

Grade F No acceptable manoeuvre

19.9 Technically unsatisfactory blows and program advice

A technically unsatisfactory blow can occur for many reasons. Below is a list of the instructions given by the program following an unsatisfactory manoeuvre (blow) and how these should be interpreted.

Table 2 Messages following unsatisfactory blows

Message	Reason	Advice
Don't hesitate...	The respondent exhaled air in short bursts	Respondent must breathe out (blast out) all the air at once, not in short bursts
Blast out faster...	The respondent did not blast the air out fast enough	The respondent must breathe out the air as fast as hard and as fast as possible
Blow out longer...	The respondent did not breathe out for long enough OR stopped when they still had air in their lungs	The respondent needs to breathe out for longer OR they need to force out as much air from their lungs as possible

Test abrupt end!	The blow stopped sooner than was expected	The respondent needs to breathe out for longer OR they need to force out as much air from their lungs as possible
Good effort, do next...	The blow was acceptable	This is an acceptable blow. They need a two more of these for the overall session to be complete
Do not start too early!	The respondent was breathing through the spirette before the program was ready	The respondent needs to wait until the screen reads 'Start manoeuvre' until they breathe through the spirette
Cough detected. Try again...	The respondent coughed while blowing	The respondent needs to avoid coughing if possible.

19.10 Technical faults and troubleshooting

Refer to Table 3 if technical difficulties are experienced with the spirometer

Table 3 Troubleshooting for the spirometer

Fault	Action
The spirometer icon does not appear at the bottom of the laptop screen after you have plugged it in	<ul style="list-style-type: none"> Check that it has been connected properly and that the USB cable has been pushed in fully to the USB port
The spirometry software will not start	<ul style="list-style-type: none"> Contact Nurse Supervisor
Calibration values vary greatly	<ul style="list-style-type: none"> Ensure the correct calibration procedure is being followed Start calibration syringe stroke sharply Ensure that you push the calibration syringe smoothly and evenly rather than jerkily Replace calibration syringe if necessary Check spirometer for external damage Ensure calibration syringe is emptied and filled fully during each stroke

If any problems persist, contact your Nurse Supervisor. If the problem continues to persist you will be advised to contact Brentwood for advice.