

Data Collection Worksheet

Please Note: The Data Collection Worksheet (DCW) is a tool to aid integration of a PhenX protocol into a study. The PhenX DCW is not designed to be a data collection instrument. Investigators will need to decide the best way to collect data for the PhenX protocol in their study. Variables captured in the DCW, along with variable names and unique PhenX variable identifiers, are included in the PhenX Data Dictionary (DD) files.

The following text describes key steps of the protocol and is taken verbatim from the WHO Pulse Oximetry Training Manual. To access the entire WHO manual please go the WHO website (http://www.who.int/patientsafety/safesurgery/pulse_oximetry/tr_material/en/).

WHAT DOES A PULSE OXIMETER MEASURE?

There are TWO numerical values obtained from the pulse oximeter monitor:

- **The oxygen saturation of haemoglobin in arterial blood.** The value of the oxygen saturation is given together with an audible signal that varies in pitch depending on the oxygen saturation. A falling pitch indicates falling oxygen saturation. Since the oximeter detects the saturation peripherally on a finger, toe or ear, the result is recorded as the peripheral oxygen saturation, described as SpO₂.
- **The pulse rate** in beats per minute, averaged over 5 to 20 seconds. Some oximeters display a pulse waveform or indicator that illustrates the strength of the pulse being detected. This display indicates how well the tissues are perfused. The signal strength falls if the circulation becomes inadequate.

A pulse oximeter is an early-warning device.

A pulse oximeter continuously measures the level of oxygen saturation of haemoglobin in the arterial blood. It can detect hypoxia much sooner than the anaesthesia provider can see clinical signs of hypoxia such as cyanosis. This ability to provide an early warning has made the pulse oximeter essential for safe anaesthesia.

THE PULSE OXIMETER:

A pulse oximeter consists of the **monitor** containing the batteries and display, and the **probe** that senses the pulse.

This picture shows a pulse oximeter. The screen shows that the SpO₂ is 98% and the pulse rate is 72 beats per minute.



THE PULSE OXIMETER MONITOR

The monitor contains the microprocessor and display. The display shows the oxygen saturation, the pulse rate and the waveform detected by the sensor. The monitor is connected to the patient via the probe.

During use, the monitor updates its calculations regularly to give an immediate reading of oxygen saturation and pulse rate. The pulse indicator is continuously displayed to give information about the circulation. The audible beep changes pitch with the value of oxygen saturation and is an important safety feature. The pitch drops as the saturation falls and rises as it recovers. This allows you to hear changes in the oxygen saturation immediately, without having to look at the monitor all the time.

The monitor is delicate. It is sensitive to rough handling and excessive heat and can be damaged by spilling fluids on it. The monitor can be cleaned by gently wiping with a damp cloth. When not in use, it should be connected to an electrical supply to ensure that the battery is fully charged.

THE PULSE OXIMETER PROBE

The oximeter probe consists of two parts, the light emitting diodes (LEDs) and a light detector (called a photo-detector). Beams of light are shone through the tissues from one side of the probe to the other. The blood and tissues absorb some of the light emitted by the probe. The light absorbed by the blood varies with the oxygen saturation of haemoglobin. The photo-detector detects the light transmitted as the blood pulses through the tissues and the microprocessor calculates a value for the oxygen saturation (SpO₂).

In order for the pulse oximeter to function, the probe must be placed where a pulse can be detected.

The LEDs must face the light detector in order to detect the light as it passes through the tissues.

The probe emits a red light when the machine is switched on; check that you can see this light to make sure the probe is working properly.

Probes are designed for use on the finger, toe or earlobe. They are of different types as shown in the diagram. Hinged probes are the most popular, but are easily damaged. Rubber probes are the most robust. The wraparound design may

constrict the blood flow through the finger if put on too tightly.

Ear probes are lightweight and are useful in children or if the patient is very vasoconstricted. Small probes have been designed for children but an adult hinged probe may be used on the thumb or big toe of a child. For finger or toe probes, the manufacturer marks the correct orientation of the nail bed on the probe.

The oximeter probe is the most delicate part of a pulse oximeter and is easily damaged. Handle the probe carefully and never leave it in a place where it could be dropped on the floor. The probe connects to the oximeter using a connector with a series of very fine pins that can be easily damaged-see diagram. Always align the connector correctly before attempting to insert it into the monitor.

Never pull the probe from the machine by pulling on the cable; always grasp the connector firmly between finger and thumb.



When not in use, the oximeter probe cable may be loosely coiled for storage or carrying, but should not be coiled too tightly as this will damage the wires inside the cable. The lens and detector should be kept clean. Use soapy water or an alcohol soaked swab to **gently** clean dust, dirt or blood from the probe.

PRACTICAL USE OF THE PULSE OXIMETER

- Turn the pulse oximeter on: it will go through internal calibration and checks.
- Select the appropriate probe with particular attention to correct sizing and where it will go (usually finger, toe or ear). If used on a finger or toe, make sure the area is clean. Remove any nail varnish.
- Connect the probe to the pulse oximeter.
- Position the probe carefully; make sure it fits easily without being too loose or too tight.
- If possible, avoid the arm being used for blood pressure monitoring as cuff inflation will interrupt the pulse oximeter signal.
- Allow several seconds for the pulse oximeter to detect the pulse and calculate the oxygen saturation.
- Look for the displayed pulse indicator that shows that the machine has detected a pulse. Without a pulse signal, any readings are meaningless.
- Once the unit has detected a good pulse, the oxygen saturation and pulse rate will be displayed.

- Like all machines, oximeters may **occasionally** give a false reading-if in doubt, rely on your clinical judgement, rather than the machine.
- The function of the oximeter probe can be checked by placing it on your own finger.
- Adjust the volume of the audible pulse beep to a comfortable level for your theatre-never use on silent.
- **Always make sure the alarms are on.**

If no signal is obtained on the oximeter after the probe has been placed on a finger, check the following:

- Is the probe working and correctly positioned? Try another location.
- Does the patient have poor perfusion?
 - o Check for low cardiac output especially due to hypovolemia, cardiac problems or septic shock. If hypotension is present, resuscitation of the patient is required immediately. The signal will improve when the clinical condition of the patient improves.
 - o Check the temperature of the patient. If the patient or the limb is cold, gentle rubbing of the digit or earlobe may restore a signal.

Tip: If you are uncertain that the probe is working properly, check it by testing it on your own finger.

WHAT DO THE ALARMS ON A PULSE OXIMETER TELL YOU?

Alarms alert the anaesthetist to clinical problems. The alarms are as follows:

- Low saturation emergency (hypoxia) i.e. SpO₂ <90%
- No pulse detected
- Low pulse rate
- High pulse rate

Low saturation alarm. The oxygen saturation in healthy patients of any age should be 95% or above.

During anaesthesia the SpO₂ should be 95% or above. If SpO₂ is 94% or below, the patient must be assessed quickly to identify and treat the cause.

SpO₂ OF < 90% IS A CLINICAL EMERGENCY AND SHOULD BE TREATED URGENTLY.

'No pulse detected' alarm is commonly caused by the probe coming off the finger, but it may also be triggered if the patient is hypotensive, hypovolaemic, or has suffered a cardiac arrest. Check the probe site quickly and then assess the patient-ABC.

Pulse rate alarms are useful to let the anaesthetist know that the heart is beating too fast or too slow. However, alert anaesthetists will have already noticed the abnormal heart rate before the alarms sound. Children normally have higher heart rates than adults, but the same oxygen saturation-see table below.

Age	Normal Heart Rate	Normal oxygen saturation (SpO ₂)
Newborn - 2 years	100 - 180	All patients should have an SpO ₂ of 95% or above during anaesthesia or during recovery from anaesthesia*
2-10 years	60 - 140	
10 years -adult	50 - 100	

* Exception: premature babies receiving oxygen therapy in the neonatal ICU should have an SpO₂ between 89-94% to avoid toxicity to the retina. During surgery the oxygen saturation of premature babies should be maintained at >95%, as with all other patients.

Light anaesthesia, inadequate pain relief, atropine, ketamine, hypovolemia, fever, or arrhythmia may trigger the high pulse alarm. The low pulse alarm may be triggered by bradycardia secondary to vagal stimulation due to e.g. peritoneal retraction, the oculocardiac reflex or intubation (particularly in babies) or from deep anaesthesia (particularly halothane) or severe hypoxia. A highly trained athlete or a patient who is taking β -blockers may have a slow pulse rate.

WHAT FACTORS CAN INTERFERE WITH THE PULSE OXIMETER READING?

Several factors can interfere with the correct function of a pulse oximeter including:

- **Light** - bright light (such as the operating theatre light or sunlight) directly on the probe may affect the reading. Shield the probe from direct light.
- **Shivering** - movement may make it difficult for the probe to pick up a signal.
- **Pulse volume** - the oximeter only detects pulsatile flow. When the blood pressure is low due to hypovolaemic shock or the cardiac output is low or the patient has an arrhythmia, the pulse may be very weak and the oximeter may not

be able to detect a signal

- **Vasoconstriction** reduces blood flow to the peripheries. The oximeter may fail to detect a signal if the patient is very cold and peripherally vasoconstricted.
- **Carbon monoxide poisoning** may give a falsely high saturation reading. Carbon monoxide binds very well to haemoglobin and displaces oxygen to form a bright red compound called carboxyhaemoglobin. This is only an issue in patients following smoke inhalation from a fire.

Hypovolemia is the most common cause of a weak pulse oximeter signal during anaesthesia. Hypothermia should also be considered.

WHAT IS NOT MEASURED BY A PULSE OXIMETER?

A pulse oximeter does not give direct information about respiratory rate, tidal volume, cardiac output or blood pressure. However, it does so indirectly and if these factors lead to desaturation, this will be detected by the pulse oximeter.

Supplemental oxygen is often essential during anaesthesia. However, be aware that it can mask the effects of hypoventilation on oxygen saturation. Clinical vigilance will be necessary to ensure that ventilation is adequate especially if a capnograph is not available.

Pulse oximeters function normally in anaemic patients. In an extremely anaemic patient, the oxygen saturation will still be normal (95%-100%), but there may not be enough haemoglobin to carry sufficient oxygen to the tissues. In cases of severe anaemia, the patient should be given 100% oxygen to breathe during anaesthesia to try to improve tissue oxygen delivery by increasing the amount of dissolved oxygen in the blood.

CAUSES OF HYPOXIA DURING ANAESTHESIA:

The causes of hypoxia during anaesthesia are summarised in the table below. **Airway obstruction is the most common cause of hypoxia.**

Source of problem	Common problem
A. Airway	<ul style="list-style-type: none">• An obstructed airway prevents oxygen from reaching the lungs• The tracheal tube can be misplaced e.g. in the oesophagus• Aspirated vomit can block the airway

<p>B. Breathing</p>	<ul style="list-style-type: none"> • Inadequate breathing prevents enough oxygen from reaching the alveoli. • Severe bronchospasm may not allow enough oxygen to reach the lungs nor carbon dioxide to be removed from the lungs. • A pneumothorax may cause the affected lung to collapse • High spinal anaesthesia may cause inadequate breathing
<p>C. Circulation</p>	<ul style="list-style-type: none"> • Circulatory failure prevents oxygen from being transported to the tissues • Common causes include hypovolemia, abnormal heart rhythm or cardiac failure
<p>D. Drugs</p>	<ul style="list-style-type: none"> • Deep anaesthesia may depress breathing and circulation • Many anaesthetic drugs cause a drop in blood pressure • Muscle relaxants paralyse the muscles of respiration • Anaphylaxis can cause bronchospasm and low cardiac output
<p>E. Equipment</p>	<ul style="list-style-type: none"> • Problems with the anaesthetic equipment include disconnection or obstruction of the breathing circuit • Problems with oxygen supply include an empty cylinder or an inadequately functioning oxygen concentrator • Problems with the monitoring equipment include battery failure in the

	oximeter or a faulty probe
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When hypoxia occurs, it is essential to decide whether the problem is with the patient or the equipment. After a quick check of the common patient problems, make sure the equipment is working properly. Always have a self-inflating bag available in case of problems with the breathing circuit.

WHAT SHOULD BE DONE WHEN THE SATURATION FALLS?

During anaesthesia, low oxygen saturations must be treated immediately and appropriately. The patient may become hypoxic at any time during induction, maintenance or emergence from anaesthesia. The appropriate response is to administer 100% oxygen, make sure that ventilation is adequate by using hand ventilation and then correct the factor that is causing the patient to become hypoxic. For example, if the patient has an obstructed airway and is unable to breathe oxygen into the lungs, the problem will only be cured when the airway is cleared.

Whenever the patient has low oxygen saturations, administer high flow oxygen and consider 'ABCDE':

- **A - airway** clear?
- **B - breathing** adequately?
- **C - circulation** working normally?
- **D - drugs** causing a problem?
- **E - equipment** working properly?

You must respond to hypoxia immediately by giving more oxygen, ensuring adequate ventilation by hand, calling for help, and proceeding through the 'ABCDE' sequence. Treat each element of the sequence as you check it. After you have been through all the checks for the first time, go back and recheck them until you are satisfied that the patient's condition has improved. WHO has put this into a chart (see full protocol) to help you remember what to look for in a logical sequence. In an emergency, there may not be time to read through the protocol. You should ask a colleague to read it aloud for you to make sure that you have not forgotten anything.

Protocol source: <https://www.phenxtoolkit.org/protocols/view/91102>