Medical Monitoring:

In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time.

It can be performed by continuously measuring certain parameters by using a medical monitor (for example, by continuously measuring vital signs by a bedside monitor), and/or by repeatedly performing medical tests (such as blood glucose monitoring with a glucose meter in people with diabetes mellitus).

Transmitting data from a monitor to a distant monitoring station is known as telemetry or biotelemetry.

Classification by target parameter

Monitoring can be classified by the target of interest, including:

- **Cardiac monitoring**, which generally refers to continuous electrocardiography with assessment of the patient’s condition relative to their cardiac rhythm. A small monitor worn by an ambulatory patient for this purpose is known as a Holter monitor. Cardiac monitoring can also involve cardiac output monitoring via an invasive Swan-Ganz catheter.
- **Hemodynamic monitoring**, which monitors the blood pressure and blood flow within the circulatory system. Blood pressure can be measured either invasively through an inserted blood pressure transducer assembly, or noninvasively with an inflatable blood pressure cuff.
- **Respiratory monitoring**, such as:
  - Pulse oximetry which involves measurement of the saturated percentage of oxygen in the blood, referred to as SpO2, and measured by an infrared finger cuff
  - Capnography, which involves CO_2 measurements, referred to as EtCO2 or end-tidal carbon dioxide concentration. The respiratory rate monitored as such is called AWRR or airway respiratory rate)
  - Respiratory rate monitoring through a thoracic transducer belt, an ECG channel or via capnography
- **Neurological monitoring**, such as of intracranial pressure. Also, there are special patient monitors which incorporate the monitoring of brain waves (electroencephalography), gas anesthetic concentrations, bispectral index (BIS), etc. They are usually incorporated into anesthesia machines. In neurosurgery intensive care units, brain EEG monitors have a larger multichannel capability and can monitor other physiological events, as well.
- **Blood glucose monitoring**

- **Childbirth monitoring**
- **Body temperature monitoring** through an adhesive pad containing a thermoelectric transducer.
- Cancer therapy monitoring through circulating tumor cells[1]

Vital parameters

Monitoring of vital parameters can include several of the ones mentioned above, and most commonly include at least blood pressure and heart rate, and preferably also pulse oximetry and respiratory rate. Multimodal monitors that simultaneously measure and display the relevant vital parameters are commonly integrated into the bedside monitors in critical care units, and the anesthetic machines in operating rooms. These allow for continuous monitoring of a patient, with medical staff being continuously informed of the changes in general condition of a patient. Some monitors can even warn of pending fatal cardiac conditions before visible signs are noticeable to clinical staff, such as atrial fibrillation or premature ventricular contraction (PVC)

Medical monitoring with chronic diseases,hospital patient and elderly patients

A medical monitor or physiological monitor is a medical device used for monitoring. It can consist of one or more sensors, processing components, display devices (which are sometimes in themselves called "monitors"), as well as communication links for displaying or recording the results elsewhere through a monitoring network

Components

Sensor

Sensors of medical monitors include biosensors and mechanical sensors. For example, photodiode is used in pulse oximetry, Pressure sensor used in Non Invasive bood pressure measurement.

Translating component

The translating component of medical monitors is responsible for converting the signals from the sensors to a format that can be shown on the display device or transferred to an external display or recording device.

Display device

Physiological data are displayed continuously on a CRT, LED or LCD screen as data channels along the time axis, They may be accompanied by numerical readouts of computed parameters on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on.

Besides the tracings of physiological parameters along time (X axis), digital medical displays have automated numeric readouts of the peak and/or average parameters displayed on the screen.

Modern medical display devices commonly use digital signal processing (DSP), which has the advantages of miniaturization, portability, and multi-parameter displays that can track many different vital signs at once.

Old analog patient displays, in contrast, were based on oscilloscopes, and had one channel only, usually reserved for electrocardiographic monitoring (ECG). Therefore, medical monitors tended to be highly specialized. One monitor would track a patient's blood pressure, while another would measure pulse oximetry, another the ECG. Later analog models had a second or third channel displayed on the same screen, usually to monitor respiration movements and blood pressure. These machines were widely used and saved many lives, but they had several restrictions, including sensitivity to electrical interference, base level fluctuations and absence of numeric readouts and alarms.

Communication links

Several models of multi-parameter monitors are networkable, i.e., they can send their output to a central ICU monitoring station, where a single staff member can observe and respond to several bedside monitors simultaneously. Ambulatory telemetry can also be achieved by portable, battery-operated models which are carried by the patient and which transmit their data via a wireless data connection.

Digital monitoring has created the possibility, which is being fully developed, of integrating the physiological data from the patient monitoring networks into the emerging hospital electronic health record and digital charting systems, using appropriate health care standards which have been developed for this purpose by organizations such as IEEE and HL7. This newer method of charting patient data reduces the likelihood of human documentation error and will eventually reduce overall paper consumption. In addition, automated ECG interpretation incorporates diagnostic codes automatically into the charts. Medical monitor's embedded software can take care of the data coding according to these standards and send messages to the medical records application, which decodes them and incorporates the data into the adequate fields.

Long-distance connectivity can avail for telemedicine, which involves provision of clinical health care at a distance.

Other components

A medical monitor can also have the function to produce an alarm (such as using audible signals) to alert the staff when certain criteria are set, such as when some parameter exceeds of falls the level limits.

Mobile appliances

An entirely new scope is opened with mobile carried monitors, even such in sub-skin carriage. This class of monitors delivers information gathered in body-area networking (BAN) to e.g. smart phones and implemented autonomous agents.

Interpretation of monitored parameters

Monitoring of clinical parameters is primarily intended to detect changes (or absence of changes) in the clinical status of an individual. For example, the parameter of oxygen saturation is usually monitored to detect changes in respiratory capability of an individual.

Change in status versus test variability

When monitoring a clinical parameters, differences between test results (or values of a continuously monitored parameter after a time interval) can reflect either (or both) an actual change in the status of the condition or a test-retest variability of the test method.

In practice, the possibility that a difference is due to test-retest variability can almost certainly be excluded if the difference is larger than a predefined "critical difference". This "critical difference" (CD) is calculated as:

$$CD = K \times \sqrt{CV_a^2 + CV_i^2}$$

, where

- K, is a factor dependent on the preferred probability level. Usually, it is set at 2.77, which reflects a 95% prediction interval, in which case there is less than 5% probability that a test result would become higher or lower than the critical difference by test-retest variability in the absence of other factors.
- CV_a is the analytical variation
- CV_i is the intra-individual variability

For example, if a patient has a hemoglobin level of 100 g/L, the analytical variation (CV_a) is 1.8% and the intra-individual variability CV_i is 2.2%, then the critical difference is 8.1 g/L. Thus, for changes of less than 8 g/L since a previous test, the possibility that the change is completely caused by test-retest variability may need to be considered in addition to considering effects of, for example, diseases or treatments.

Examples and applications

The development cycle in medicine is extremely long, up to 20 years, because of the need for U.S. Food and Drug Administration (FDA) approvals, therefore many of monitoring medicine solutions are not available today in conventional medicine.

Blood glucose monitoring

In vivo blood glucose monitoring devices can transmit data to a computer that can assist with daily life suggestions for lifestyle or nutrition and with the physician can make suggestions for further study in people who are at risk and help prevent diabetes mellitus type 2 .

Stress monitoring

Bio sensors may provide warnings when stress levels signs are rising before human can notice it and provide alerts and suggestions. Deep neural network models using photoplethysmography imaging (PPGI) data from mobile cameras can assess stress levels with a high degree of accuracy (86%).

Serotonin biosensor

Future serotonin biosensors may assist with mood disorders and depression.

Continuous blood test based nutrition

In the field of evidence-based nutrition, a lab-on-a-chip implant that can run 24/7 blood tests may provide a continuous results and a computer can provide nutrition suggestions or alerts.

Psychiatrist-on-a-chip

In clinical brain sciences drug delivery and in vivo Bio-MEMS based biosensors may assist with preventing and early treatment of mental disorders

Epilepsy monitoring

In epilepsy, next generations of long-term video-EEG monitoring may predict epileptic seizure and prevent them with changes of daily life activity like sleep, stress, nutrition and mood management.

Toxicity monitoring

Smart biosensors may detect toxic materials such mercury and lead and provide alerts.

Remote patient monitoring for chronic disease management

Remote patient monitoring for chronic disease management is an effective solution for patients with chronic disease. According to the Journal of Medical Internet Research, telemonitoring is a valid alternative to usual care, reducing mortality and improving disease self-management in patients who report satisfaction and adherence. Because chronic diseases are the leading cause of death and disability nationwide.

A remote patient monitoring program uses technology to transmit data from a patient's home to the clinician for review and intervention. The patient is provided with an RPM medical device that allows them to measure specific vital signs from the comfort of their homes. Clinicians receive that information in real-time and can access it whenever they want.

By implementing RPM, clinicians can significantly reduce healthcare costs and promote better allocation of resources for improving chronic disease management. Here are 3 reasons why remote patient monitoring can transform chronic disease management:

1). Promotes Early Identification of Chronic Disease

Most patients only see their doctor when their condition becomes problematic, or it's time for their next appointment. But what if something goes wrong in-between visits? If the patient doesn't know what to look for, complications will continue to develop.

Remote patient monitoring for chronic disease management promotes better care in-between visits. By keeping track of patients' vital signs regularly, clinicians will better understand their patients' conditions and be alerted immediately if medical attention is necessary. The RPM device sends real-time readings to the remote patient monitoring platform for the clinician to access immediately.

Clinicians will automatically be alerted for quick action when a patient's reading is above or below the set threshold. RPM promotes the early identification of chronic diseases. Furthermore, the earlier complications are identified, the sooner patients can get treatment and minimize the progression of chronic disease.

2). RPM Prompts Adjustments to Treatment Plans

Another way remote patient monitoring helps improve chronic care management is through timely adjustments to treatment plans. Through the RPM portal, clinicians can check how their patients are doing whenever they want. As a result, they can see how their patients respond to medications and adjust prescriptions as necessary.

Without RPM, many patients go months with an ineffective or unoptimized treatment plan. Remote patient monitoring in chronic disease management can help patients find a treatment plan that works for them while reducing chronic disease progression.

3). Remote Patient Monitoring Increases Patient Engagement

We all know how to live healthier lives, but it's challenging to consistently apply those practices to your everyday life. Remote patient monitoring is about expanding healthcare outside the conventional hospital setting and into the patient's daily lifestyle. It helps patients feel supported in managing their health. Because they know that their care providers regularly check their health data, patients are more likely to engage in healthier lifestyle choices and adhere to their management plans.

Patients play an essential role in remote patient monitoring for chronic disease management. They're responsible for taking their vital sign measurement at least 16 days a month. While this provides clinicians with valuable insight, it also helps the patients engage and better understand their condition. Regular measurements allow patients to recognize a normal range for their bodies. They can see if their health is improving or worsening over time and how changes to their lifestyle choices affect their readings.

The better the patient understands their condition and engages, the more likely they are to practice healthier behaviors, keep an eye out for complications, and communicate with their clinician.

Using Remote Patient Monitoring for Chronic Disease Management

Using RPM, chronic disease patients are much less likely to be admitted into hospitals, use emergency departments, and require complicated procedures. This significantly reduces healthcare costs.

Remote patient monitoring improves the management of various chronic diseases, including:

- Stroke
- Heart disease
- Diabetes
- Chronic heart failure
- Kidney disease
- Chronic obstructive pulmonary disorder

Depending on the patient's condition, different vital signs must be monitored. For example, individuals at risk of stroke or kidney disease will benefit from using a blood pressure monitor, while those with diabetes will need to keep an eye on their blood glucose levels.

1. Remote Patient Monitoring Blood Pressure Monitors

Blood pressure monitors are RPM devices that help individuals with hypertension ensure their blood pressure stays within a healthy range. Hypertension is a major risk factor for many chronic diseases like heart failure and stroke. Clinicians can identify complications early and provide prompt treatment by effectively keeping track of a patient's blood pressure between visits. A blood pressure monitor will display systolic blood pressure, diastolic blood pressure, and heart rate.

The top number is the systolic blood pressure measurement. This indicates the amount of pressure in the arteries when your heart is beating. According to the American Heart Association, any reading above 130 mmHg is considered hypertensive. The second number is the diastolic blood pressure measurement. This is the amount of pressure in between heartbeats. Any reading above 80 mmHg is considered hypertensive.

How to Use

Most top RPM digital blood pressure monitor devices are very user-friendly, making them ideal for remote use. Tenovi's BPM works right out of the box, eliminating the hassle of device setup.

For the best results, encourage your patients to:

- Relax for about 5 minutes before
- Sit comfortably and avoid crossing their legs
- Keep their arm rested on top of a table or armrest
- Empty their bladder
- Measure around the same time every day
- Avoid eating, exercise, caffeine, and alcohol for at least half an hour before
- Take the measurement twice, about a minute apart, to ensure accuracy, and then average the numbers

To use a blood pressure monitor, wrap the cuff around the upper arm (ensure the cuff is on bare skin, not clothing) and press the middle button. The cuff will start inflating, take the blood pressure measurement, and then automatically send the data to the RPM platform.

2. Remote Patient Monitoring Scales

Weight gain of 3 or more pounds in a single day can indicate congestive heart failure. Congestive heart failure occurs when the heart cannot efficiently pump blood throughout the body. At-risk individuals typically experience shortness of breath, tightness in the chest, and dizziness. While it is entirely normal for weight to fluctuate, weight gain in at-risk patients can serve as a precursor to more serious conditions. By monitoring a patient's body weight, clinicians can quickly identify signs of heart failure and focus on early management.

How to use
All the patient has to do is step on the scale to turn it on and wait for the reading. The information will automatically send to the clinician, and the RPM device will turn off on its own.

For the most accurate results, advise patients to:

- Weigh themselves at the same time every day (preferably the morning)
- Avoid eating or drinking right before the weigh-in
- Wear the same clothing for each weigh-in or weigh without clothes on

Regular bodyweight measurements can help healthcare providers evaluate the effectiveness of a patient's management plan and, if necessary, quickly make adjustments to better control fluid retention.

3. Remote Patient Monitoring Blood Glucose Meters
Diabetes is the 7th leading cause of death in the United States and the 4th most common cause of physician visits. If poorly managed, diabetes can cause kidney failure, heart attack, stroke, and blindness. By utilizing a blood glucose meter to remotely monitor blood sugar levels, clinicians can better assess whether a patient's treatment management plan is working and make adjustments to optimize care.

How to Use
Tenovi's Blood Glucose Meter is a top-line FDA-cleared RPM device. It includes a cell-enabled meter, lancet, and custom test strips that make measuring blood sugar very simple.

Gather all the materials and perform the following steps with clean hands:

1. Insert the test strip into the meter
2. Wipe your finger with an alcohol pad and let dry
3. Gently prick the side of the finger with the lancet
4. Place a drop of blood onto the test strip and wait for the reading

Most patients should aim for blood glucose levels between 80-130mg/dL before a meal or below 180 mg/dL in about 2 hours after a meal. If patients' blood glucose levels are too high, they may need to adjust their diet or medications.

4. Remote Patient Monitoring Peak Flow Monitors

Learning to use a peak flow meter for asthma care offers several advantages. One of the most significant benefits is the ability for physicians and patients to evaluate and pinpoint the causes of asthma flare-ups and determine the most effective treatment options for the specific lung condition. Remote monitoring of peak flow enables healthcare providers to identify if medication or treatment adjustments are required promptly.

How to Use

To begin using the Tenovi peak flow meter, relax for a few minutes before closely following these **3 easy steps.**

1. Turn it on. Press the power button for 3 seconds and wait for the Gateway to start flashing yellow.
2. Take a reading: Take a deep breath, then exhale quickly into the peak flow meter.
3. Data transfer: PEF and FEV1 data will automatically transfer to the Tenovi cloud or clinician portal.

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5. Remote Patient Monitoring Pulse Oximeters

Another remote patient monitoring device in healthcare that is useful for assessing lung disease is a pulse oximeter. A pulse oximeter measures heart rate and oxygen saturation in a patient's red blood cells. Patients with conditions that affect blood oxygen levels, like heart attack, heart failure, COPD, anemia, lung cancer, asthma, and pneumonia, may benefit from regular pulse oximetry.

How to Use

Pulse oximetry is typically tested at the fingertips to measure how well oxygen is being sent to areas of your body furthest from the heart. This RPM is simple to use.

To use the Tenovi Pulse Oximeter, all the patient has to do is:

- Turn on the device. Place a finger inside the slit, and wait for the reading. A pulse oximeter uses light to measure the amount of oxygen in your blood at a given point.
- Pulse oximeters will show blood oxygen saturation level (SpO2) and pulse rate.
- Patients should seek medical attention if their reading indicates:
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- SpO2 under 90% (hypoxia)
- Low pulse rate
- High pulse rate

Most remote top remote patient monitoring devices will notify the healthcare provider immediately as well.

6. Remote Patient Monitoring Digital Thermometers

RPM cellular thermometers are used for body temperature monitoring for early infection detection where timely treatment is crucial. This is especially true in the case of sepsis. RPM digital thermometers are remote patient monitoring devices used in cancer care, to monitor COVID-19 and postoperative patients. Regular temperature monitoring reveals symptom patterns and serves as a warning signal when abnormalities arise.

How to Use

Patients should follow these 3 easy steps to use the Tenovi RPM thermometer.

1. Turn it on: Press the blue power button and wait for the Gateway to start flashing yellow.
2. Take a reading: Point the thermometer to the center of the forehead (1-3 cm away) and press the blue button.
3. Data transfer: The temperature measurement data will automatically transfer to the clinician portal.