An Update of Insulin Delivery Options is supported by Novo Nordisk Inc. This program has been accredited by AADE for pharmacists, nurses, and dietitians.

The goal of this program is to increase awareness about the important role of insulin delivery systems in helping patients meet their individual therapeutic goals.
The following program is a taped presentation by Virginia Peragallo-Dittko.

Virginia Peragallo-Dittko has been the Director of the Diabetes Education Center at Winthrop-University Hospital in Mineola, NY since 1985. She holds academic appointments as clinical associate faculty for graduate education at City University of New York, Hunter-Bellevue School of Nursing, Molloy College Department of Nursing, and Adelphi University School of Nursing.

She serves as Editor-in-Chief of program publications for the American Diabetes Association. In 1990, Ms. Peragallo-Dittko was named Diabetes Educator of the Year by the American Association of Diabetes Educators and was named 2002 Diabetes Educator of the Year and 2004 Administrator of the Year by the Metropolitan New York Association of Diabetes Educators. She is editor of the textbook, A Core Curriculum for Diabetes Education, second edition and addendum. She has been published in the area of diabetes education in books as well as lay and professional journals. Ms. Peragallo-Dittko has lectured extensively for both lay and professional audiences and has participated in both radio and television interviews.
Objectives

- Describe at least three barriers to starting insulin therapy and some available countermeasures
- Discuss advantages and disadvantages of insulin pen/doser use
- Describe three insulin delivery systems in addition to vial and syringe
- State at least two patient survey responses regarding insulin pen use
- Discuss advantages and disadvantages of insulin pump use

This program will address the important role of insulin delivery systems in helping patients meet their individual therapeutic goals. By the end of this program you should be able to:

- Describe at least three barriers to starting insulin therapy and some available countermeasures
- Discuss advantages and disadvantages of insulin pen/doser use
- Describe three insulin delivery systems in addition to vial and syringe
- State at least two patient survey responses regarding insulin pen use
- Discuss advantages and disadvantages of insulin pump use
Healthcare professionals are well aware that diabetes is a debilitating and costly disease that is reaching epidemic proportions. An estimated 18.2 million Americans have diabetes mellitus. The Centers for Disease Control and Prevention state that 13 million Americans have diagnosed diabetes and an estimated 5.2 million Americans have undiagnosed diabetes.

Diabetes management requires continuous medical care and comprehensive self-management education to meet target goals, prevent acute complications, and reduce the risk of long-term complications. All appropriate treatment options can and should be used to help individuals with diabetes meet their goals.

It is exciting to note that today, technological advances provide numerous insulin delivery options that offer a variety of choices to healthcare teams and to people with diabetes.
Diabetes: An Overview

- **Type 1**
  - 5% - 10% of patients with diabetes
  - Produce little or no insulin

- **Type 2**
  - 90% - 95% of patients with diabetes
  - Produce some insulin of their own at onset; production diminishes with time

- **Gestational Diabetes**
  - Diabetes that develops during pregnancy
  - Affects 7% of pregnant women (200,000 cases annually)

It is helpful to review the types of diabetes using the most current terminology. In the past, patient age at onset was considered the primary difference between type 1 and type 2 diabetes. Today, the appropriate distinction has nothing to do with age; rather the distinction centers on physiology and how much insulin the beta cells of the pancreas produce.

In type 1 diabetes, the pancreas produces little or no insulin. Treatment with insulin is required to sustain life. Type 1 diabetes accounts for 5 to 10% of the total number of individuals diagnosed with diabetes in the United States. Type 1 diabetes was formerly known as juvenile-onset or insulin-dependent diabetes.

In the United States, approximately 90 to 95% of individuals with diabetes have type 2 diabetes. The physiology of type 2 diabetes encompasses both insulin resistance and progressive failure of the pancreatic beta cell. Because of the progressive nature of type 2 diabetes, many of these patients may eventually require insulin therapy. It is important to note that there is an alarming increase in the number of children and adolescents diagnosed with type 2 diabetes. You can see that former terminology of adult-onset or non-insulin dependent diabetes is completely outdated.

Diabetes diagnosed during pregnancy is referred to as gestational diabetes. Screening and aggressive treatment may help contribute to a healthy outcome for both mother and fetus. Women who have had gestational diabetes are considered high risk for developing type 2 diabetes later in life.
Inadequate diabetes control and management is common in the United States.

<table>
<thead>
<tr>
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<th>Percentage</th>
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<tr>
<td>A1C &gt;7%</td>
<td>57%</td>
</tr>
<tr>
<td>BP &gt;140/90 mmHg</td>
<td>34%</td>
</tr>
<tr>
<td>LDL &gt;130 mg/dL</td>
<td>58%</td>
</tr>
<tr>
<td>No A1C test</td>
<td>71%</td>
</tr>
<tr>
<td>No dilated eye exam</td>
<td>37%</td>
</tr>
<tr>
<td>No foot exam</td>
<td>45%</td>
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Clinical trials of 10 years duration, involving thousands of patients with type 1 and type 2 diabetes have proven conclusively that keeping blood glucose levels close to target range can delay, mitigate, or even prevent the long-term complications of diabetes.

Despite this strong evidence, most patients in the United States are not meeting monitoring or treatment goals. This was demonstrated by an analysis of data collected from 1988 to 1994 from 1,026 participants with diabetes in the 3rd U.S. National Health and Nutritional Examination Survey (NHANES III) and 3,059 patients with diabetes in the Behavioral Risk Factors Surveillance System.

Using the outcome measures associated with avoiding diabetes complications, 57% of patients had A1C levels greater than the goal of 7%.

The treatment goal for blood pressure is 130/80 or less, yet 34% had blood pressure measurements greater than 140/90.

The target goal for LDL-cholesterol, an important marker for the prevention of coronary artery disease, is less than 100 mg/dL for most people with diabetes and less than 70 mg/dL for high risk patients, yet this data revealed that 58% had an LDL-cholesterol reading greater than 130 mg/dL.

Sadly, 71% did not have a A1C measured, 37% had no dilated eye exam, and 45% had no foot exam.
### Some Perceived Barriers to Insulin Therapy

- Needle phobia or fear of injection pain
- Embarrassment of injecting in public
- Fears about hypoglycemia (both patient and physician)
- Concern about having to change lifestyle
- Fear that insulin therapy means the “end of the road”

Patients with type 2 diabetes may resist treatment with insulin or insulin analogs. This is often called psychological insulin resistance and it may be caused for various reasons including:

- needle phobia or fear of discomfort
- embarrassment of injecting in public
- fears about hypoglycemia
- concern about having to change their lifestyle
- symbolism attached to insulin therapy. Some people associate insulin with personal failure, serious decline in health or for some, insulin is considered the “end of the road.”
### Some Remedies for Psychological Insulin Resistance

- Information about new insulin delivery systems and disposable needles
- Education about hypoglycemia
- Education about hyperglycemia and risk of complications
- Information about disease progression given early in treatment

A patient’s transition to insulin therapy can be eased by anticipating psychological insulin resistance. Acknowledge that most people are hesitant to make the transition to insulin, offer common reactions, and ask the patient to describe his or her concerns. Based on the patient’s response, the following can be offered:

- If the patient voices concern about discomfort or practical lifestyle issues, describe the new insulin delivery systems with small needles and virtually no discomfort adding that many patients report that the use of insulin pens or dosers makes it more comfortable to inject in public places.

- If the patient is concerned about hypoglycemia, review the emphasis on prevention. Sometimes starting with a single injection lowers blood glucose enough so that the patient sees the benefit of insulin therapy but does not experience hypoglycemia.

- It is important to provide education about hyperglycemia and the risk of complications, including discussion of maintaining glucose targets. In a recent survey, only 23% of patients believed that insulin would help them control their diabetes.

- Sometimes, well intentioned efforts encouraging patients to use lifestyle modification to lower blood glucose include using insulin therapy as a threat. Be sensitive to how insulin therapy is discussed. Present insulin as one of many treatments for diabetes, not the last resort.

- We have all heard stories of patients who fear insulin because someone they know started insulin and lost vision, had an amputation, or died. Fear that insulin is associated with a downward spiral may be mitigated by gently explaining that the person was suffering from the effects of long term hyperglycemia, not insulin therapy.
Check Point

What percentage of people with diabetes in the US do not receive an A1C examination?
   a. 45%
   b. 57%
   c. 71%

What percentage of people with diabetes in the US do not receive an A1C examination?
   a. 45%
   b. 57%
   c. 71%
c.

71% of people with diabetes in the US do not receive an A1C examination.

The answer is letter c.
71% of people with diabetes in the US do not receive an A1C exam.
Insulin delivery systems that are safe, accurate, and easy-to-use have changed the approach to managing diabetes with insulin. Patients have the benefit of a variety of insulin delivery systems including vial and syringe with the use of injection and insertion aids, jet injectors, durable and disposable insulin pens and dosers, and insulin pumps.

A study by Peyrot and Rubin demonstrated that self-care behaviors have an effect on clinical outcomes. One particular behavior that lowered A1C was improvement in insulin administration such as skipping fewer injections and improving dose adjustment. If an insulin delivery device helps a patient take multiple injections or make decisions about dose adjustment based on blood glucose, then the insulin delivery system becomes a valuable treatment tool.
Administration by vial and syringe has been the primary insulin delivery system since the 1920s, when exogenous insulin was introduced for the management of diabetes. It remains the most widely used system in the United States. Syringes are relatively inexpensive and permit in-syringe mixing of different types of insulin. There may be better options, however, for the visually and physically impaired, for those who travel extensively or lead active lives, and for those who are afraid of needles.

The initial assessment of the insulin-requiring patient includes checking the patient’s injection technique and use of the insulin delivery system. For the patient using the vial and syringe method of insulin delivery, the assessment includes whether the syringe matches the insulin dose. If the dosage is less than 30 units of insulin, use a 3/10 cc syringe. For greater than 30 but less than 50 units of insulin, use a 1/2 cc syringe. And if the dose to be injected is greater than 50 units, use a 1 cc syringe.

Needle choices include the length of the needle and gauge of the needle. 5/16 or 1/2 inch needles may be prescribed. Needle gauges vary from 28 to 31 gauge with 31 representing a thinner needle.

Reimbursement issues are critical to the prescription of insulin delivery systems. If an insurer will not reimburse for the product that meets a patient’s needs, the decision can be appealed. Outline the medical benefits and use research findings to support the position.
Medication Errors with Vial and Syringe

- **System issues**
  - Prescribing (wrong dose or product)
  - Order writing (ie, “U” confused with “0”)

- **Product and administration**
  - Wrong syringe selected
  - Incorrect dose drawn into syringe
  - Wrong product selected
  - Inadequate mixing of suspensions
  - Patient inability to administer drug correctly

System-wide safety issues concerning insulin include writing all insulin doses using the word units not the abbreviation letter U. We should also be alert to sound-alike medications such as Lantus and Lente. Always repeat the name and dosage for verification.

Patient safety is central to prescribing. Part of the insulin delivery selection process includes assessing the safety needs of a patient. The potential errors surrounding the vial and syringe delivery system include:
- Wrong syringe selected
- Incorrect dose drawn into the syringe
- Wrong product selected
- Inadequate mixing of suspensions and
- The patient’s inability to administer the insulin using a syringe.
Several aids have been developed to facilitate accurate insulin delivery using the vial and syringe system:

- Syringe magnifiers enlarge the calibration marks on the syringe. Patients should try using syringe magnifiers before purchasing, as for some patients, magnifiers distort the image rather than enlarge it.
- A needle guide and vial stabilizer help with needle insertion by holding vial and syringe together while the syringe is being filled with insulin. These tools are especially helpful for patients with tremors, fluctuating vision, or elderly patients.
- For non-visual insulin measurement, there is a syringe-filling device that produces an audible click with each unit of insulin drawn into the syringe and another precalibrated system is available with Braille or raised numbers. Some products can be used with any syringe while others are designed to work with a specific brand.

A different type of injection aid, used separately from a syringe, is a subcutaneous infusion set consisting of a flexible catheter that remains beneath the skin for 48-72 hours. Insulin is injected through an external port.
Insertion aids facilitate and accelerate insertion of the needle into the skin for patients who are reluctant to do it themselves or who have difficulty injecting insulin into hard-to-reach areas, such as the buttocks.

They work through the use of a spring-loaded plastic or metal syringe holder that is positioned over the skin. The needle, which is hidden from view in many devices, is inserted subcutaneously by activating a button or pressing the device against the skin. Once the needle is inserted, the patient manually pushes the plunger to deliver insulin. Some devices also aid in pushing down the plunger.

Insertion aids can be used with 1 cc, 1/2 cc, or 3/10 cc syringes. In most models, the depth of skin penetration is adjustable for very thin or obese people.

The photo in the slide shows BD’s Automatic Injector, INJECT-EASE.
Another option for insulin delivery is the jet or hydraulic injector. Jet injectors deliver insulin transcutaneously by an air-jet mechanism instead of using a needle. They release a fine, high-pressure stream of insulin that penetrates the skin.

Four manufacturers produce jet injectors for the US market:
- Activa Brand Products, Inc.
- Equidyne Systems, Inc.
- Antares Pharma, Inc.
- Bioject, Inc.

The Medi-Jector Vision from Antares Pharma, Inc. is pictured.
Jet Injectors

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Portable, discreet</td>
<td>Bruising or “tattooing” of skin is possible</td>
</tr>
<tr>
<td>Needleless</td>
<td>Mechanically complex</td>
</tr>
<tr>
<td>Reduced risk of cross-contamination</td>
<td>Some older models must be cleaned and sterilized</td>
</tr>
<tr>
<td></td>
<td>Not well studied in trials</td>
</tr>
<tr>
<td></td>
<td>Not widely used</td>
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Jet injectors may be the insulin delivery system of choice for those with a true needle phobia. They can cause bruising and may actually traumatize the skin if used incorrectly. At the injection site, some patients develop permanently discolored skin called tattooing. Some may find use of these systems complicated, cumbersome and mechanically complex. For others, the jet injector is the only way that they can administer insulin. Jet injectors are not widely used and have not been well studied in clinical trials.
Accuracy of dose can be a problem when vial and syringe delivery is used.

a. True  b. False
Check Point

True.

Medication errors are common with vial and syringe.

The correct choice is true. Medication errors are common with the vial and syringe method of insulin delivery.
### Insulin Pens and Dosers

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<thead>
<tr>
<th><strong>Advantages</strong></th>
<th><strong>Disadvantages</strong></th>
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<tbody>
<tr>
<td>Portable, compact</td>
<td>Limited to available insulin formulations</td>
</tr>
<tr>
<td>Discreet</td>
<td>Cannot self-mix (except for Disetronic pen)</td>
</tr>
<tr>
<td>Permit flexibility of lifestyle</td>
<td></td>
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<tr>
<td>Consistent accuracy of dosing</td>
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The primary advantages of insulin pens and dosers, as compared to vial and syringe, are their portability and convenience. They are discreet, result in a consistent dose delivery, permit a more flexible lifestyle, and eliminate the need to draw up insulin.

One disadvantage of pens and dosers is that they are limited to premixed formulations available for pen use. If an individual wants to inject both NPH and Regular at the same time in a ratio different from the available premixed formulations, two pens and two injections are required.
Preparation Prior to Use of Insulin Pens and Dosers

- Review user instructions for each insulin delivery pen or doser for cartridge insertion (durable pens)

- Before each injection, patient should perform an “air shot” to ensure insulin delivery (durable or disposable)

When teaching patients to use insulin pens or dosers it is important to include the following:

- As part of the instruction, patients should actually demonstrate their ability to use it correctly. Manufacturers’ instruction materials should be followed for proper needle attachment, dose selection, and correction. For durable pens and dosers, patients should also follow the instructions for cartridge insertion.

- All cloudy insulin formulations must be thoroughly resuspended before injection. Cartridges and prefilled pens must be turned end-over-end at least 10 times or until the insulin has been completely resuspended.

- Following manufacturers’ instructions, patients should perform an “air shot” before each injection. In order to ensure that the insulin in the pen or doser reaches the needle, attach a needle to the device, select the dose stated in the instructions, hold the device with the needle pointing upward, and push the button. Insulin should appear at the tip of the needle. If it does not, the procedure should be repeated until insulin appears.

- After injection, the pen or doser should remain in place for a few seconds to ensure complete delivery.
Insulin pens offer patients many options. When the patient chooses an insulin pen, assessment includes matching the products available to the patient’s needs. Consider the formulation of insulin, disposable prefilled versus durable pens, whether the pen delivers insulin in one or half unit increments, and the patient’s total dose per injection.

A disposable prefilled pen is shaped like a traditional writing pen. Instead of a writing point, there is a disposable insulin needle and instead of ink, the prefilled pen is already filled with insulin when it is purchased. Once the prefilled pen is empty, the entire unit is discarded.

NovoLog FlexPen contains 3mL of NovoLog. NovoLog Mix 70/30 FlexPen contains 3mL of NovoLog Mix (70% insulin aspart protamine suspension and 30% insulin aspart injection). These pens deliver from one to 60 units in one unit increments. The NovoLog FlexPen is pictured.

In one study with a sample of 105 participants, 74% preferred the FlexPen to the vial and syringe and considered it easier to use; 85% believed the pen to be more discreet.
Humulin® Pen
- 3mL syringe prefilled with U-100 insulin
- One-unit increments
- 1-60 units

NPH and 70/30 formulations

Humulin Pen is a 3mL insulin pen that delivers up to 60 units of insulin in one-unit increments; it contains one of the following human insulin formulations in a prefilled, disposable syringe:
- Premixed 70/30 (70% NPH human insulin isophane suspension and 30% Regular human insulin)
- NPH (human insulin isophane suspension)
Humalog® Pen
- Prefilled with 3mL of Humalog®

Humalog® Mix75/25 Pen
- Prefilled with 3mL of Humalog® Mix75/25™

1-unit increments, 1-60 units

Humalog Pen contains 3mL of Humalog, a rapid-acting insulin analog.

Humalog Mix75/25 Pen contains 3mL of Humalog Mix75/25 (75% insulin lispro protamine and 25% insulin lispro).

These pens deliver from one to 60 units in one-unit increments. The Humalog Mix75/25 Pen is pictured.
The durable insulin pen is shaped like a traditional ink-cartridge writing pen; instead of a writing point, there is a disposable needle, and instead of an ink cartridge, there is a cartridge containing one of several available insulin formulations. When the insulin cartridge is empty, it is discarded and a new cartridge is loaded into the pen. The pen itself is not disposable.

NovoPen 3 uses 3mL cartridges and offers dosing in one-unit increments with 2-70 units per injection.

NovoPen Junior uses 3mL cartridges and offers dosing in half-unit increments with 1 to 35 units per injection.

NovoPen 3 and NovoPen Junior are designed for use with 3mL PenFill cartridges of Novolin N (NPH), Novolin 70/30, or Novolin R (Regular). They can also be used with 3mL NovoLog cartridges and 3mL NovoLog Mix 70/30 cartridges.

NovoPen3 PenMate is an accessory that conceals the needle on the NovoPen 3 and NovoPen Junior. In one study of 57 participants, it was shown to reduce perception of pain.
Durable Insulin Pens

Disetronic® Pen

- One-unit increments
- 1-80 units
- Large electronic display
- Allows mixing insulin types in an open refillable cartridge

The durable-type Disetronic pen has an open 3.5mL refillable cartridge that can be filled with any type of insulin, insulin analog, and/or mixture of compatible insulins. It offers dosing in one-unit increments with 1 to 80 units per injection. A large electronic display shows the number of units selected and delivered.
Two models of the durable-type Autopen multidose insulin injection systems are available in the United States:

Model 3810 offers dosing in one-unit increments with 1 to 21 units per injection.

Model 3800 offers dosing in two-unit increments with 2 to 42 units per injection.
Opticlik™

- Uses 3mL Lantus® cartridges
- 1-unit increments
- 1-80 units per injection

Opticlik is a durable-type insulin pen that uses 3mL cartridges of Lantus, which is insulin glargine, a long-acting insulin analog.

Opticlik offers dosing in one-unit increments with 1 to 80 units per injection.
Advantages of administering insulin with insulin pens include their ease of use and accuracy of dosage.

a. True  
b. False
True.

The ease of use and easy-to-read dose selectors make consistent accurate dosing possible.

The correct choice is true. The ease of use and easy-to-read dose selectors make consistent, accurate dosing possible.
In a study of patient preferences, 803 insulin-using patients were asked to use a prefilled insulin pen and compare it to the vial and syringe method of insulin delivery.

When we consider the demands of managing diabetes with insulin, any impact that the healthcare professional can have on lessening the burden is critical. The survey participants reported improvements surrounding lifestyle issues that are associated with treatment. A significant number of patients reported that they were more willing to take insulin both at home and away from home while using the prefilled disposable pen. It is important to note that 85% reported fewer missed injections when using the prefilled disposable pen. This finding has an impact on clinical outcomes as evidenced in the study by Peyrot and Rubin discussed earlier in this program.
In another survey, 507 insulin-using patients were asked to use an insulin pen for three weeks and compare it to vial and syringe administration. The following results were reported:

- 73% believed the pen’s dosing mechanism was more accurate.
- 89% thought that the pens were more socially acceptable than vial and syringe, and that they felt more comfortable using them in public.
- 98% reported that they found the pens easy to use.
- 97% said they would continue to use the pen and that they would recommend it to others.

Patient satisfaction, indeed.
### Insulin Delivery Systems: Patient Survey Results

**Prefilled disposable pen containing a suspension of premixed insulin analog (70/30) vs. vial and syringe**

**Responses**
- Efficacy benefits were greatest in those who had never used insulin
- Those new to an insulin pen reported greatest improvement in convenience and flexibility
- All five groups responded with an overall preference for pen

N= 372

In another study of 372 patients with type 2 diabetes, patients were divided into 5 treatment groups based on their prior treatment. All groups overwhelmingly preferred a prefilled pen containing a suspension of protamine-crystallized insulin aspart and a rapid-acting insulin analog (70/30) to using a vial and syringe.

Efficacy benefits were greatest in the group who had never used insulin, but those who had previously used only syringes to deliver unmixed insulin reported the greatest overall benefits on outcomes such as convenience, flexibility, and quality of life.
Insulin Delivery Systems: Patient/Physician Survey Results

Prefilled disposable syringe containing short-acting human insulin or rapid-acting insulin analog vs. vial and syringe

**Responses**
- Would continue to use pen: 78%
- Would recommend pen: 80%

**Physicians**
- Took less time to teach: 88%
- Took less time to initiate insulin therapy: 73%

N= 299

In this study, 299 patients with type 1 or type 2 diabetes were asked to use the Humalog Pen for six weeks; 78% reported that they would continue to use the pen and 80% would recommend the pen to others.

33 physicians completed questionnaires at the end of the study. 97% thought the pen was better overall when compared with vial and syringe, 88% believed it took less time to teach, and 73% thought it took less time to initiate insulin therapy with the pen.
Insulin doser is a term used to describe an insulin delivery system that is either disposable or durable but is not shaped like a writing instrument or pen. The term insulin doser more accurately describes these delivery systems.

Novolin InnoLet is a prefilled, handheld injection device that features a large kitchen timer-like dial with an easy-to-read scale. It clicks audibly for each unit dialed and has a support shoulder that provides stability. The Novolin InnoLet delivers one to 50 units of human insulin in one-unit increments.

Novolin InnoLet comes preloaded with a cartridge containing 3mL of either Novolin N (NPH), Novolin 70/30 (70% NPH and 30% Regular), or Novolin R (Regular). The device is disposed of when the cartridge is empty.

In a recent study with 79 participants, patients who had visual and/or motor disabilities and had difficulty injecting with a vial and syringe were randomized to vial and syringe or Novolin InnoLet for a 6-week period. 53% could independently administer insulin when using Novolin InnoLet, as opposed to 20% when using vial and syringe. 82% indicated a preference for Novolin InnoLet.
Innovo is a compact, handheld injection device that delivers insulin doses from 1-70 units in one-unit increments and is compatible with Novo Nordisk 3mL PenFill cartridges.

It has a large, clear dose display and a dose selector that can be dialed up or down to adjust insulin dose.

A unique feature of Innovo is a built-in memory function that displays the amount of the previous dose as well as the time elapsed since the previous dose was delivered.
Combined Insulin Doser and Blood Glucose Monitor

InDuo®

- Combines glucose monitoring and insulin dosing
- Tests blood glucose using the ONE TOUCH® system; results available in 5 seconds
- Delivers 1–70 units insulin in one-unit increments
- Compatible with 3mL PenFill® cartridges
- Memory function displays amount of previous dose and time since administered

The dose of insulin injected before a meal is decided based on the patient’s premeal blood glucose reading plus the anticipated content of the meal. To provide premeal injection, patients carry supplies for both skills – blood glucose monitoring and insulin delivery. InDuo, a compact device that combines a blood glucose monitor with an insulin doser, meets this need. It was designed to encourage blood glucose monitoring at the time of injection.

The glucose monitor uses One Touch Ultra test strips. The InDuo blood glucose monitor has a large display and provides blood glucose test results in just 5 seconds, storing these results in the system memory. Blood glucose results can be downloaded to a personal computer using InTouch software available from LifeScan.

The insulin doser component of InDuo is the durable Innovo doser. It is compatible with Novo Nordisk 3mL PenFill cartridges. The memory function displays the previous dose and estimated time since insulin was administered.
Insulin Pumps

- **Open-loop systems**
  - External insulin pumps: continuous subcutaneous insulin infusion (CSII)
  - Implantable insulin pumps (used in research only)

- **Closed-loop systems**
  - Biostater (artificial pancreas) (used in research only)

Insulin pumps offer another option for insulin delivery.

Open-loop insulin pumps are categorized as either external insulin pumps also known as continuous subcutaneous insulin infusion or as implantable insulin pumps. They are called open-loop systems because they are activated by the patient, who determines insulin doses based on frequent blood glucose monitoring and food choices.

The implantable insulin pump is currently available only under research protocol use; it requires a surgical procedure for placement.

Despite the lack of a feedback-controlled mechanism, external and implantable open-loop systems represent a significant step toward more physiologic insulin delivery and improved glycemic control. Insulin pumps can be used by patients with type 1 or type 2 diabetes and provide an alternative to multiple injections of insulin.

Because insulin pumps continuously infuse insulin into the body, the safe and effective use of these systems requires appropriate training and frequent self-monitoring of blood glucose so that proper dosage decisions can be made.

A closed-loop pump, or artificial pancreas, has a computer-controlled feedback system in which an infusion pump is programmed to administer insulin based upon the blood glucose concentration measured by a glucose sensor. A semi-closed-loop system is currently in development; it is comprised of a sensor, a hand-held computer, and a small pump.
### Continuous Subcutaneous Insulin Infusion (CSII)

- Basal/bolus insulin delivery via flexible tube with needle inserted subcutaneously
- Basal rate is continuous, so no peak absorption of subcutaneous insulin
- Only rapid-acting insulin analogs are approved for pump use

External insulin pumps are roughly the size of a pager and are comprised of an insulin reservoir, a small battery-operated pump, and a computerized control mechanism. In most pumps, insulin reservoirs must be filled by the patient. Insulin is delivered through a flexible plastic tube, with or without a small needle, which is inserted subcutaneously and taped into place.

The insulin pump can be programmed to deliver both basal and bolus doses. Basal or background insulin is provided by a slow, steady infusion of insulin over a 24-hour period. Pumps can be programmed to deliver different basal rates throughout the 24-hour period, reducing the risk of hypoglycemia or hyperglycemia.
Continuous Subcutaneous Insulin Infusion (CSII)

- Patient determines bolus dose before each meal, providing flexibility and convenience
- Requires frequent blood glucose monitoring (≥ four times daily)
- Careful patient selection is crucial to avoid adverse events

When using an insulin pump, the patient selects and delivers the bolus or meal time dose before each meal or snack. The bolus dose is determined by the preprandial blood glucose concentration and the type and amount of food the patient will eat at that meal.

All pumps have alarm systems to alert the user to catheter problems and low levels of insulin in the reservoir.

Patients who choose insulin pump therapy require sophisticated skills for diabetes self-management. They are willing to check their blood glucose levels frequently throughout the day and learn how to coordinate their blood glucose levels with adjustments in the basal and bolus insulin infusion rates.
Insulin pump models currently available include the following:

- The Animas IR1000 contains an insulin-filled cartridge and has a battery-operated pump motor that delivers insulin every 3 minutes. Basal rates can be programmed from 0.05 to 9.9 units per hour and bolus doses from 0.1 to 25 units in increments of 0.1 units. Animas IR1200 contains a bolus calculator.

- The Deltec Cozmo contains a 300 unit disposable plastic reservoir and a battery-operated pump motor with a status indicator that shows the amount of insulin left. Basal doses are delivered in 3 minute intervals and up to 48 basal rates can be programmed. It delivers bolus doses from 0.05 to 75 units. Increments can be customized.

- DANA Diabecare USA manufactures the DANA Diabecare II. It has a 300 unit insulin reservoir, plus an automatic display of remaining insulin and battery life. Basal rates can be programmed from 0.01 to 16 units per hour with 24 possible rates and a guided management feature.
Nipro Diabetes Systems manufactures Amigo. Basal rates can be set from 0 to 10 units per hour in 0.05 unit increments.

Medtronic MiniMed’s Paradigm 515/715 is pictured. It contains a reservoir similar to a syringe and a battery-operated pump motor. Basal rates can be programmed from 0.5 to 35 units per hour and bolus doses from 0.1 unit increments. It contains a bolus calculator. The 508 pump is no longer available for purchase in the US, but is supported.

Disetronic Medical Systems, Inc. is no longer selling pumps in the US but supplies and technical support continue to be provided.
Insulin Pumps

- **Advantages**
  - Increased precision in insulin dosing
  - Increased flexibility in lifestyle
  - No need for multiple injections

- **Disadvantages**
  - Potential for inflammation and infection at infusion site
  - Susceptibility to ketoacidosis
  - Potential for catheter occlusion
  - Initial purchase expensive

Insulin pumps offer several advantages to patients for insulin delivery:

- Pumps increase the precision of insulin dosage.
- Insulin absorption is more stable and predictable than with a multiple-injection regimen, which may increase the potential for improved glycemic control.
- The delivery closely mimics physiologic insulin secretion patterns, especially when used with a rapid-acting insulin analog.
- They are discreet, and permit a flexible lifestyle.

Disadvantages include:

- The potential for inflammation and infection at the infusion site; manufacturers recommend changing the site every 2 to 3 days.
- There is a possibility of ‘kinking’ of the catheter. All pumps have alarms to alert the patient to “no delivery.”
- Other mechanical problems include leakage, battery problems, and the remote possibility of generalized mechanical failure. These systems must be carefully monitored for insulin supply, cleanliness, battery charge level, and mechanical function.
- Initial cost is high and pump use may not be possible for all patients.
Many insulin delivery systems are in development and are under study.

A portable closed-loop insulin pump would incorporate continuous blood glucose monitoring with insulin delivery. The blood glucose results would determine insulin delivery rates. The major barrier to the development of a true "artificial pancreas" is the difficulty in developing a small, reliable, durable, and accurate glucose sensor. Other questions include which body fluid should be used (blood, saliva, peritoneal, or cerebrospinal) and how the sensor will be kept in contact with that fluid on a permanent basis.

Ligand-bound insulin is another potential insulin delivery system. Insulin, bound to a lectin or polymer, is competitively displaced by glucose. Therefore, as the glucose concentration increases, more insulin is released.

Several new routes of insulin delivery in development include pulmonary, transdermal, buccal, intranasal, and ocular. Pulmonary insulin is in various stages of clinical development. These routes deliver insulin without injection; however, poor bioavailability and the significant variability in absorption associated with them may make them problematic.

Encapsulation and microencapsulation of islet cells are being attempted in order to protect transplanted islets against immune rejection. One way is to encapsulate the cells in tubing made of biocompatible material or microencapsulate the cells in tiny beads that will protect the cells from the immune system while allowing them to react to ambient glucose.

Technological advances in the pipeline offer hope to the millions of people with diabetes.
Involvement in their own diabetes management is not required when people use insulin pens, dosers, or pumps.

a. True       b. False
Check Point

False.

Patients must participate in their own management regardless of the insulin delivery system used; patients using pumps must be especially vigilant about their blood glucose levels.

The correct choice is false. Patients need to participate in their own management regardless of the insulin delivery system used. Patients using pumps must be especially vigilant about their blood glucose levels.
Summary

To help patients manage diabetes:

- Educate and inform
- Supply tools
- Simplify
- Empower
- Support

Patients resist insulin therapy because of perceived discomfort, inconvenience, and emotional issues. Healthcare professionals can offer a variety of insulin delivery tools that are designed to address each barrier by providing flexibility, ease of delivery, and convenience. We are challenged to listen to patients’ concerns about insulin therapy, address their needs, and offer the abundance of options provided through insulin delivery systems.