

Continuous Glucose Monitors (CGMs)

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Goals of This Presentation

- ▷ Learn about what a CGM is & how it benefits people living with Type 1 diabetes (T1D)
- ▷ Learn about the pros and cons of current CGMs
- ▷ Learn about what users think the perfect CGM would be like
- ▷ Learn about CGM hacks

Outline

1. What is a CGM?
2. My Timeline of T1D
3. Loop
4. Interviewed CGM Users
5. Comparing CGMS
 - a. Photos of each CGM
 - b. General
 - c. Accessibility
 - d. Sensor Insertion
 - e. Sensor & Transmitter
 - f. Analytics
 - g. Summary
6. How We Can Use CGM Data
7. Hacks
8. Sources
9. Photo Credits
10. Thank you!

What is a CGM?

A CGM reads blood sugar numbers every few minutes, and it is very helpful for people living with diabetes.

CGMs have a small electrode that gets blood sugar numbers from the interstitial fluid under the skin. This electrode is held on by an adhesive. The CGM then wirelessly sends the blood sugar number to a phone, insulin pump, and/or monitor.

The CGM is helpful because it means less pokes (twice a day to none) than with fingersticks (multiple daily), and it gives a continuous stream of data that can inform decisions to prevent hyper- and hypoglycemia.

My Timeline of T1D



Shots
Finger sticks

The vast majority of people living with diabetes use shots and finger sticks.



Insulin pump

About 30-40% of people living with T1D use insulin pumps.



CGM

Over 30% of people living with T1D in the US use CGMs. I have been able to use the Dexcom G7, G7 Plus, G4, G5, and G6. I have also been able to use the Medtronic Guardian Sensor 1 and 3.



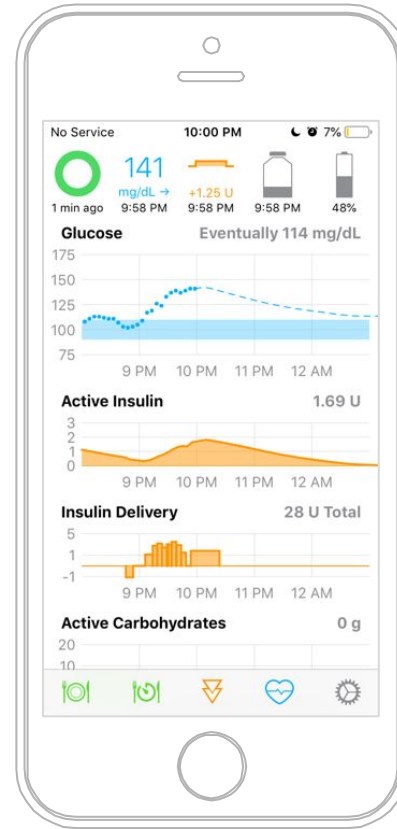
Loop

Hardly anyone uses Loop.

Loop

Find out more about
Loop [here](#)

- ▷ Basal rate modulator
- ▷ DIY system



Interviewed CGM Users

Jill McInerney, T1D parent

- ▷ T1D for 2 years
- ▷ Now 11 years old
- ▷ Dexcom G5 ⇒ Dexcom G6

Minoo Taheri, T1D parent

- ▷ T1D since December 2016
- ▷ Now 10 years old
- ▷ Dexcom G5 ⇒ Dexcom G6

Kelly Close, founder of The diaTribe Foundation & president of Close Concerns, Inc.

- ▷ T1D for over 30 years
- ▷ Adult
- ▷ Using Dexcom G6, Abbott FreeStyle Libre, & Senseonics
- ▷ Used Medtronic before

Beth Sorenson, T1D parent

- ▷ Now 19 years old
- ▷ T1D for 6.5 years
- ▷ Dexcom ⇒ FreeStyle Libre ⇒ Eversense

Courtney Cameron, T1D parent

- ▷ T1D for 8.5 years
- ▷ Now 9 years old
- ▷ Medtronic ⇒ Dexcom G4 ⇒ Dexcom G5

Cheryl Swenson, T1D parent

- ▷ T1D for over 4 years
- ▷ Now 5.5 years old
- ▷ Using CGM since September 2016
- ▷ Dexcom G5 ⇒ Dexcom G6 (2018)

Lacey Ford, T1D parent

- ▷ Dexcom G4 ⇒ Dexcom G6
- ▷ T1D for 3.5 years
- ▷ Now 5 years old

Sarah Levy, T1D parent

- ▷ Now 17 years old
- ▷ T1D for 16.5 years
- ▷ Dexcom G5 ⇒ Dexcom G6

Comparing CGMs

Dexcom G6, Dexcom G5, Abbott FreeStyle Libre,
Medtronic Guardian Sensor 3, & Senseonics Eversense

Dexcom G6 (2018)



1.6 x 0.85 x 0.32
inches



Dexcom G5 (2015)



1.5 x 0.9 x 0.5
inches



Abbott FreeStyle Libre (2017)

Sensor Applicator



Sensor Pack



Sensor
(assembled)

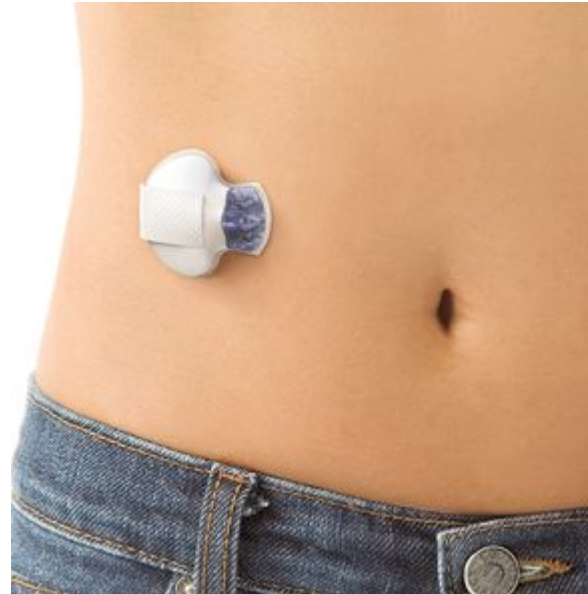
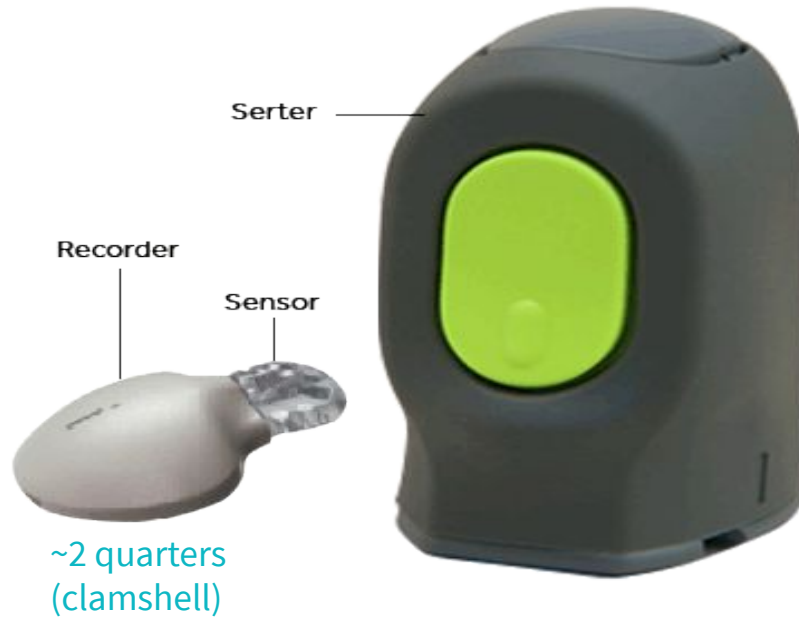


1.378 x 1.378 x 0.197
inches

Reader



Medtronic Guardian Sensor 3 (2017)

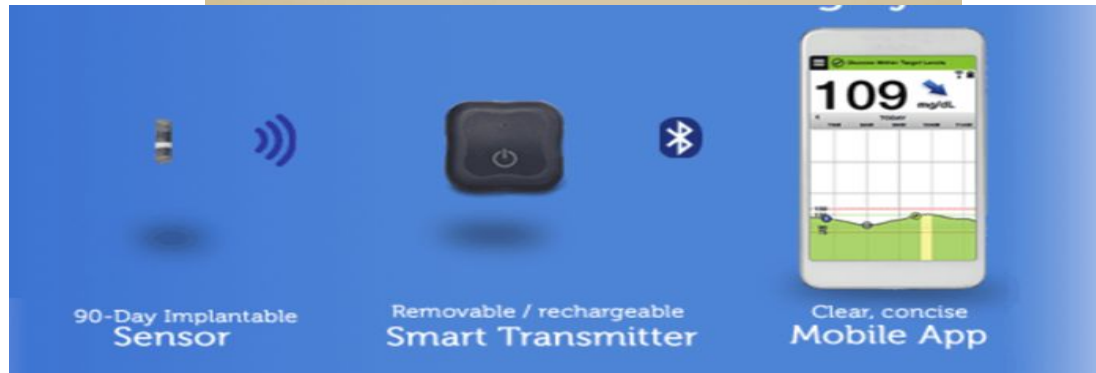


Senseonics Eversense (2018)

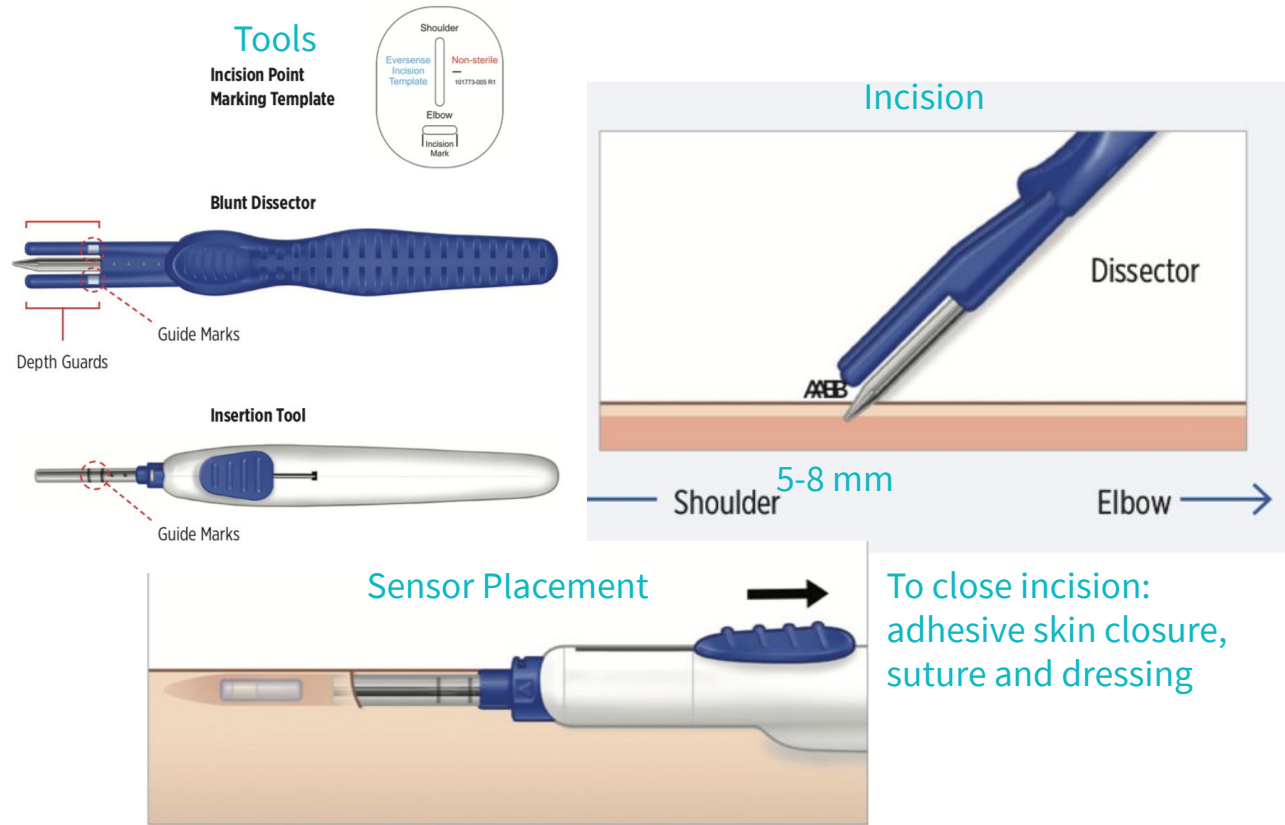


Transmitter: 1.480 x
1.890 x 0.346

Sensor: 0.327 x 0.138
inches



Senseonics Eversense (2018): Surgery



Comparing CGMs: General

| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense | Ideal CGM |
|-------------------------------------|----------------------------------------------------------------------------------|----------------------------------------|------------------------------------------------|--------------------------------------|------------------------------------------------|--------------------------------------------------------------------------|
| Target customers | T1D; lots of data without fingersticks | T1D; lots of data | T2D; minimize diabetes time | T1D; 670G users; reduce hypoglycemia | No needles | Works for all |
| Fingerstick calibrations | 0 ; “Meghan rarely does any finger pokes anymore.” —Jill McInerney | 2 | 0 | 2 | 2 | 0; stop calluses; CGMS more accurate than fingerstick meters |
| Alarms at high and low blood sugars | Yes; “I have stopped using the app on my phone because of [alarms].” —Sarah Levy | Yes (Courtney Cameron’s favorite part) | No; need to scan the sensor to see blood sugar | Yes | Yes “I love that it vibrates!” —Kelly Close | Less annoying, prevent emergencies “Customizable alarms.” —Sarah Levy |
| <u>Loop</u> | Yes | No | No | No | No | “Everyone would have access to Loop.” —Kelly Close |
| Trust | High (all); 80% Lacey Ford | 90% (Courtney Cameron) | Pretty good | Not great | High | “100% reliable.” —Kelly Close |

Comparing CGMs: Accessibility

| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense | Ideal CGM |
|------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------------------------------------------------------|---------------------------------|--------------------------------------------------------------------------------------------|
| Places to view data | Android & iPhone, receiver, smartwatch, Tandem t:slim X2 pump, Share | Android & iPhone, receiver, smartwatch, Share; “The follow app has gotten worse.” –Courtney Cameron | iPhone & receiver | 670G pump & iPhone Guardian Connect app; “I like interoperability.” —Kelly Close | Android & iPhone | As many as possible; Share prevents emergencies; “Integrated with pump.” —Courtney Cameron |
| Ages | 2+ | 2+ | 18+ | 7+ for 670G; 14+ for Guardian Connect | 18+ | All ages |
| Medicare Coverage | Yes | Yes with conditions | Yes | No | No | Yes |
| Medicaid Coverage | Yes | Yes | Yes | No** | No** | Yes |
| Total cost (insurance covers most) | Expensive (about \$7-8 per day) | Expensive | Less expensive (about \$4-5 per day) | Expensive (about \$7-8 per day) | Expensive (about \$7-8 per day) | Not expensive |

Comparing CGMs: Sensor Insertion

| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense | Ideal CGM |
|----------------------|---------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Insertion difficulty | “Easy and fast.” & “Not painful.” –Jill McInerney & Minoo Taheri | “I should have had medical training.” –Jill McInerney | “I love how easy it is.” —Kelly Close | Difficult; “It really really hurt.” —Kelly Close | Surgery; “So much better to have the implant and not have to deal with insertion each time!” -Beth Sorenson | Not invasive |
| Sensor wear length | 10 days*; Most want to make it last longer | 7 days*; “Easy to extend past the 7 day mark to 14 days.” –Jill McInerney | 14 days | 7 days | 90 days (180 in the future), replace adhesive patch daily | Minimize pokes & inconvenience; “Wear for months or years.” —Courtney Cameron |
| Insertion | Very large, disposable; “So much environmental waste.” —Kelly Close | Large, disposable | Small | Very large, reusable | Surgery | Not invasive |
| Warm Up Length | 2 hours | 2 hours | 1 hour | 2 hours | 24 hour warm up after procedure | “No warm up.” —Jill McInerney; prevent emergencies; more data |

Comparing CGMs: Sensor & Transmitter

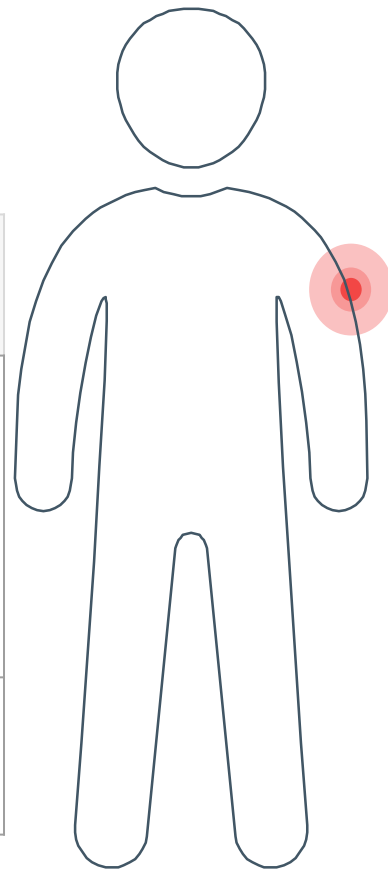
| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense | Ideal CGM |
|-----------------------------------------------|--------------------------|------------------------|------------------------------------------------------------------|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Sensor size | 1.6 x 0.85 x 0.32 inches | 1.5 x 0.9 x 0.5 inches | 1.378 x 1.378 x 0.197 inches “Very discreet.” —Kelly Close | ~2 quarters (clamshell) | Sensor: 0.327 x 0.138 inches Transmitter: 1.480 x 1.890 x 0.346 Kelly Close loves how it's not visible. | Not noticeable; “Smaller; would come in whatever shape I wanted.” —Minoo Taheri |
| Transmitter life | 3 months* | 3 months* | Disposable | Rechargeable | Rechargeable | Rechargeable |
| MARD (difference between fingerstick and CGM) | 9.0% | 9.0% | 9.4% | 9.6%; “The accuracy was a problem.” –Kelly Close | 8.8% | 0% MARD; “Reduce the delay on the readings.” —Jill McInerney; we act on CGM data |
| Adhesive | Bad | Okay | “She started to get skin irritations.” -Beth Sorenson | Confusing | “Can be taken off and put back on as needed.” -Beth Sorenson | None so less inconvenience & skin irritation |

Comparing CGMs: Analytics

| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense | Ideal CGM |
|-------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------|----------------------------------------|----------------------|------------------------------------------------------------------------------------------------------|
| Name of system | Dexcom Clarity | Dexcom Clarity | Libre View | Medtronic | None | |
| Features | Rebound of highs/lows; GMI; average BG; TIR; AGP; graphs “I can't imagine needing anything more.” –Jill McInerney | Rebound of highs/lows; GMI; average BG; TIR; AGP; graphs “I love how encouraging [the notifications about TIR] are.”–Kelly Close | Average BG; TIR; AGP; graphs | TIR; estimated A1C; average BG; graphs | None | As many as possible: rebound of highs/lows, GMI, average bg, TIR, AGP, graphs |
| Other platforms | Tidepool, Sugarmate, Undermyfork, gluc (most) | Tidepool, Sugarmate, Undermyfork(most) | Undermyfork | Undermyfork | None | As many as possible |
| User friendliness | Yes; scalable | Yes; scalable | Not great; mostly for HCPs | No; for HCPs | None | Scalable for HCPs & patients; “Make things more encouraging. ... Should be one app.” —Kelly Close |

Comparing CGMs: Summary

| | Dexcom G6 | Dexcom G5 | Abbott Freestyle Libre | Medtronic Guardian Sensor 3 | Senseonics Eversense |
|------------|---------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------|-----------------------------------|------------------------------|
| Love it | Minoo Taheri Lacey Ford Kelly Close Jill McInerney Cheryl Swenson Sarah Levy | ~Courtney Cameron | Kelly Close | | Kelly Close Beth Sorenson |
| Dislike it | | Minoo Taheri Sarah Levy Beth Sorenson | Beth Sorenson | Kelly Close | |



How We Can Use CGM Data

- ▷ Evaluate new devices (like Tidepool Loop)
- ▷ Which one is more: hypo- or hyperglycemia
 - ▶ Adjust pump settings to be more/less aggressive
- ▷ Give data (about average A1C, average bg, etc.) to customers/users —Kelly Close
- ▷ Do Dexcom G6 users use the full 10 days?
- ▷ Issues with Loop & safety concerns \Rightarrow change them
- ▷ Average basal rates, insulin to carb ratio, & insulin sensitivity factors across ages/weights
 - ▶ Easier for newly diagnosed
- ▷ After long high bg, need more insulin to come down?
 - ▶ If yes, more aggressive after long high bgs
 - ▶ Same for low?

*Hacks

| | Dexcom G6 | Dexcom G5 |
|-------------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| Sensor | Learn here (complex & involves putting the receiver in the microwave!) | Learn here ; simply stop the sensor and restart it |
| Transmitter | Learn here (option #3 & #4 ⇒ complex) | Learn here (complex) |



- ▷ <http://www.diabetes.org/newsroom/press-releases/2015/insulin-pumps.html>
- ▷ [DexcomG5 vs DexcomG6 Size.jpg](#)
- ▷ <https://beyondtype1.org/comparing-the-dexcom-g6-to-the-g5/>
- ▷ <https://hcp.medtronic-diabetes.com.au/guardian-sensor-3>
- ▷ <http://diabetesviews.com/2016/11/senseonics-everSense-an-implantable-cgm/>
- ▷ <https://www.senseonics.com/investor-relations/news-releases/2016/11-11-2016-001613716>
- ▷ <https://abbott.mediaroom.com/2018-07-27-Abbotts-FreeStyle-R-Libre-14-Day-Flash-Glucose-Monitoring-System-Now-Approved-in-US?platform=hootsuite>
- ▷ [Newswirehttps://www.prnewswire.com/...releases/fda-approves-dexcom-g5-mobile-continuous-...](https://www.prnewswire.com/...releases/fda-approves-dexcom-g5-mobile-continuous-...)
- ▷ <https://diatribe.org/fda-approves-senseonics-everSense-90-day-implantable-cgm-body-...>
- ▷ <https://www.medicaldevice-network.com/projects/senseonics-everSense-continuous-glucose-monitoring-system/>
- ▷ <https://diatribe.org/continuous-glucose-monitors>
- ▷ <https://care.diabetesjournals.org/content/41/8/1579>
- ▷ <https://www.senseonics.com/~media/Files/S/Senseonics-IR/documents/publications/implantable-cgm-with-daily-transmitter-adhesive-demonstrates-high-use-compliance-in-180-day-pivotal-trial.pdf>
- ▷ <https://www.bcdiabetes.ca/dexcom-g5-hack-extending-sensor-life-up-to-28-days/>
- ▷ <https://seemycgm.com/2018/05/03/reset-g5-transmitter/>
- ▷ [FDA Approves Dexcom G6 - Beyond Type 1](#)
- ▷ <https://beyondtype1.org/fda-approves-dexcom-g6/>
- ▷ <https://www.dexcom.com/fingersticks>
- ▷ <https://beyondtype1.org/comparing-the-dexcom-g6-to-the-g5/>
- ▷ <https://www.dexcom.com/faq/g5-mobile>
- ▷ <https://www.youtube.com/watch?v=qjCWxPWxJY>
- ▷ <https://diatribe.org/freestyle-libre-now-available-major-us-pharmacies>
- ▷ <https://www.fda.gov/media/112159/download>
- ▷ <https://www.dexcom.com/about-dexcom>
- ▷ <https://www.fool.com/retirement/general/2015/05/19/medicaid-vs-medicare-the-key-differences-you-need.aspx>

Photo Credits

- ▷ <https://www.fda.gov/media/112159/download>
- ▷ [Sensor-belly-shot.png](#)
- ▷ [5andG6.jpg](#)
- ▷ [Android-block-v4_mobile.jpg](#)
- ▷ [G6-familyshot_2_0_0.png](#)
- ▷ [Headerdxcn.png](#)
- ▷ [Download](#)
- ▷ [94462644-full.jpg](#)
- ▷ [Sensor-serter.png](#)
- ▷ [Medtronic-Continuous-Glucose-Monitoring-696x487.png](#)
- ▷ [Eversense-fda-approval-2.png](#)
- ▷ <https://youtu.be/VZ6s5fEVI04>
- ▷ [Loop_adam_5.png](#)

Thank you for listening!

I hope you enjoyed my presentation!