



# CIGNA MEDICAL COVERAGE POLICY

The following Coverage Policy applies to all plans administered by CIGNA Companies including plans administered by Great-West Healthcare, which is now a part of CIGNA.

Effective Date ..... 3/15/2009  
Next Review Date..... 3/15/2010  
Coverage Policy Number ..... 0106

**Subject Home Blood Glucose Monitors**

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## Hyperlink to Related Coverage Policies

- Diabetes Self-Management Education
- Diabetic Supplies
- External Insulin Pumps
- Implantable Infusion Pumps
- Nutritional Counseling

### INSTRUCTIONS FOR USE

Coverage Policies are intended to provide guidance in interpreting certain **standard** CIGNA HealthCare benefit plans as well as benefit plans formerly administered by Great-West Healthcare. Please note, the terms of a participant's particular benefit plan document [Group Service Agreement (GSA), Evidence of Coverage, Certificate of Coverage, Summary Plan Description (SPD) or similar plan document] may differ significantly from the standard benefit plans upon which these Coverage Policies are based. For example, a participant's benefit plan document may contain a specific exclusion related to a topic addressed in a Coverage Policy. In the event of a conflict, a participant's benefit plan document **always supercedes** the information in the Coverage Policies. In the absence of a controlling federal or state coverage mandate, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of 1) the terms of the applicable group benefit plan document in effect on the date of service; 2) any applicable laws/regulations; 3) any relevant collateral source materials including Coverage Policies and; 4) the specific facts of the particular situation. Coverage Policies relate exclusively to the administration of health benefit plans. Coverage Policies are not recommendations for treatment and should never be used as treatment guidelines. Proprietary information of CIGNA. Copyright ©2009 CIGNA

## Coverage Policy

Coverage for home blood glucose monitors is subject to the terms, conditions and limitations of the applicable benefit plan's Durable Medical Equipment (DME) benefit and schedule of copayments. In addition, coverage for home blood glucose monitors may be governed by state mandates. Please refer to the applicable benefit plan document to determine benefit availability and the terms, conditions and limitations of coverage. Under many benefit plans, coverage for DME is limited to the lowest-cost alternative.

If coverage for home blood glucose monitors is available, CIGNA covers the following devices as medically necessary when the associated criteria are met:

- a standard home blood glucose monitor as medically necessary for any individual with diabetes mellitus
- enhanced feature glucose monitors (e.g., large readout, audio monitor, integrated lancing/blood sample) as medically necessary in the management of diabetes mellitus in individuals who have visual or other physical impairments and are able to self-monitor and self-administer insulin

CIGNA covers a minimally invasive, continuous glucose monitoring system (CGMS) as medically necessary for ANY of the following:

- up to three days (72 hours) under the core medical benefits of the plan for the management of difficult to control insulin-treated diabetes mellitus for up to six separate sessions in any given 12-month period

- long-term use in type 1 diabetics who are age 25 years or older
- long-term use in type 1 diabetics who are less than age 25 years AND have recurrent, severe hypoglycemic events (i.e., blood glucose < 50 mg/dL) despite appropriate modifications in insulin therapy and compliance with frequent self monitoring of blood glucose (i.e., at least four times daily)
- long-term use in type 2 diabetics with recurrent, severe hypoglycemic events (i.e., blood glucose < 50mg/dL) despite appropriate modifications in insulin therapy and compliance with frequent self monitoring of blood glucose (i.e., at least four times daily) with ONE of the following combinations of laboratory findings:
  - a fasting C-peptide level that is  $\leq 110\%$  of the lower limit of normal of the laboratory's measurement method AND a concurrently obtained fasting glucose  $\leq 225$  mg/dL
  - renal insufficiency with a creatinine clearance (actual or calculated from age, gender, weight and serum creatinine)  $\leq 50$  ml/minute AND a fasting C-peptide level that is  $\leq 200\%$  of the lower limit of normal of the laboratory's measurement method

**CIGNA does not cover additional software or hardware required for downloading data from blood glucose monitors to computers for the management of diabetes mellitus because it is considered a convenience item and is not medically necessary.**

**CIGNA does not cover ANY of the following because they are considered experimental, investigational or unproven:**

- alternative site blood glucose monitors
- GlucoWatch® G2™ Biographer

**CIGNA does not cover combination devices that include a home blood glucose monitor combined with a cellular telephone or other device not specifically indicated for the management of diabetes mellitus (e.g., blood pressure monitor, cholesterol screening analyzer) because such combination devices are considered convenience items and not medically necessary.**

## General Background

Blood glucose monitors (BGMs) measure blood glucose concentration using a reagent strip, cartridge or cuvette and a drop of capillary blood from a finger puncture. Used at home, portable BGMs allow those with diabetes to detect and treat fluctuations in blood glucose levels. The normal fasting blood glucose concentration ranges from 70–100 milligrams (mg) per deciliter (dL) in blood serum or plasma, although capillary blood glucose concentrations may be higher (e.g., by 10–15%). A person with diabetes can adjust insulin dosage, food intake, and exercise in response to the monitor's readings to achieve normoglycemia. Frequent blood glucose monitoring to maintain normoglycemia facilitates treatment designed to reduce the incidence and severity of diabetes-related microvascular and neurological complications.

Most BGMs are automatic and require no user intervention to operate. The test strip is inserted into the monitor either before or after the addition of blood to the strip. Timing begins automatically when the monitor senses blood on the strip. A few BGMs are manual and require reaction timing and wiping of the reagent strip. Some manual and automatic monitors require a color comparison of the color of the reacted reagent area to a chart to estimate blood glucose concentration. The concentration estimates from color charts are only semiquantitative, since they are influenced by ambient lighting and vision, thus yielding less accurate results than the automatic BGMs.

Some portable BGMs use reflectance photometry to measure the amount of light produced by a light emitting diode (LED) and reflected from a reagent-impregnated test pad that has reacted with a drop of blood. Reflectance colorimeter devices used for measuring blood glucose levels in clinical settings are not covered as durable medical equipment for use in the home. Their need for frequent professional recalibration makes them unsuitable for home use. Other units use absorbance photometry, an optical reading method that measures glucose concentration using two wavelengths, rather than the single wavelength used by reflectance photometry.

Electrochemical BGMs (e.g., One Touch<sup>®</sup> Ultra2<sup>®</sup>, LifeScan, Inc., Milpitas, CA) use electrodes to measure the current that is produced by the conversion of glucose to gluconic acid via glucose oxidase, glucose dehydrogenase, or hexokinase when blood is applied to the test strip. The resulting current is directly proportional to the amount of glucose in the sample. These automatic devices require no reaction timing or reagent-strip wiping. Manual BGMs that require timing and wiping are reliable only if the operator adheres strictly to the testing procedure. The purchase of a BGM that require wiping is not recommended. Monitors with the least number of steps are least susceptible to errors or variations (ECRI, 2008).

### **Standard Home Blood Glucose Monitoring**

The American Diabetes Association (ADA) recommends finger-stick self-monitoring of blood glucose (SMBG) as an integral component of diabetes therapy for type 1 and type 2 diabetics, as well as diabetes during pregnancy (maternal diabetes) or diabetes that develops during pregnancy (i.e., gestational diabetes). They also stress that the patient/caregiver should receive instructions in, and routine follow-up of, SMBG technique and their capability to use the data to adjust therapy (ADA, 2009a). The ADA reports that clinical trials assessing the impact of glycemic control on diabetes complications have included SMBG as part of multifactorial interventions, suggesting that SMBG is a component of effective therapy. SMBG allows patients to evaluate their individual response to therapy and assess whether glycemic targets are being achieved. Results of SMBG can be useful in preventing hypoglycemia and adjusting medications, medical nutrition therapy (MNT), and physical activity. Because the accuracy of SMBG is instrument- and user-dependent, it is important for health care providers to periodically evaluate each patient's monitoring technique.

The ADA's recommendations for home blood glucose testing by patients include:

- "SMBG should be carried out three or more times daily for patients using multiple insulin injections or insulin pump therapy
- For patients using less frequent insulin injections, noninsulin therapies, or medical nutrition therapy (MNT) alone, SMBG may be useful in achieving glycemic goals.
- To achieve postprandial glucose targets, postprandial SMBG may be appropriate
- When prescribing SMBG, ensure that patients receive initial instruction in, and routine follow-up evaluation of, SMBG technique and their ability to use data to adjust therapy"(ADA, 2009a).

The following features should be considered when purchasing a home glucose monitor:

- Analytical ranges should be checked under the conditions in which it is to be used.
- Since accuracy may be measured by differing reference methods by manufacturer, the user should be aware of the reference used.
- The monitor should offer precision in measuring the reproducibility of test results, as expressed in a low variation coefficient.
- Performance reliability should be checked using check strips or solutions to validate that the results are within the limits set by the ADA.
- The monitor should be simple to use and require minimal training to obtain reliable results. Displays should be large enough to read easily. Operation control buttons should not have multiple functions. Required codes should be easy to enter.
- Safety features should include strips designed for that unit only and should provide error messages for extremely high or low blood glucose levels.
- Memory and data management capabilities should store at least 10 glucose readings. The monitor should be capable of reading from memory if the battery is removed for changing.
- Battery-powered operation should include low battery indicators to warn of low battery power. Monitors should use commonly available batteries.
- Monitors should be able to withstand rough handling and disassembly for cleaning or battery replacement.
- The monitor should be easy to clean, and cleaning instructions should be supplied by the manufacturer (ADA, 2008a; ECRI, 2008a)

**U.S. Food and Drug Administration (FDA):** The standard glucose monitor and test strips are approved under the Class II, 510(k) process for the purpose of providing quantitative measurement of glucose in whole blood.

Examples of home blood glucose meters approved by the FDA include: Accu-Chek<sup>®</sup> (Roche Diagnostics, Indianapolis, IN), Freestyle<sup>®</sup> (Therasense, Inc., Alameda, CA), Ascensia<sup>®</sup> (Bayer HealthCare, Mishawaka, IN), and One Touch<sup>®</sup> (LifeScan, Inc., Milpitas, CA).

**Literature Review:** As recommended by the ADA, the use of SMBG is the standard of care for diabetic patients. The evidence in the peer-reviewed literature including meta-analysis, systematic reviews, randomized controlled trials and case series reported statistically significant decreases in hemoglobin A1c (HbA1c or A1c) in SMBG subjects, an increased regularity of medication usage, improved glucose control and better metabolic control in type 1 and type 2 (n=1307–19,491), insulin and non-insulin treated diabetics (Soumerai, et al., 2004; Sarol, et al., 2005; Schutt, et al., 2006).

The National Institute for Clinical Excellence (NICE) (United Kingdom) advises on the use of SMBG by type 1 adult diabetic in conjunction with appropriate insulin regimens and diabetic education. Meters and strips should be chosen based upon the needs of the individual patient. Frequency of SMBG should be based upon the characteristics of the individual's glucose control, the insulin regimen and personal preference in using results to achieve desired lifestyle (NICE, 2008c).

Regarding the management of type 2 diabetes, NICE recommends that SMBG be available to newly diagnosed diabetics, individuals who are insulin-treated or are on oral glucose lowering medications to “assess changes in glucose control resulting from medications and lifestyle changes,” “to monitor changes during intercurrent illness,” and “to ensure safety during activities”. They encourage an annual assessment of SMBG skills and state if SMBG is unacceptable to the individual, urine glucose monitoring may be an alternative method (NICE, 2008a).

#### **Enhanced Feature Glucose Monitors**

Audio monitors are available for the patient who has severe visual impairment. The monitor gives instructions and results verbally, allowing the patient to use the equipment without assistance. Monitors are also available with large readouts for those with impaired vision. BGMS may have various other features, such as speaking in Spanish and data management systems (ADA, 2008a). The Prodigy Glucose Meter (Diagnostic Devices, Inc., Deerfield, IL) is an example of an FDA-approved audio blood glucose monitor.

#### **Home Continuous Glucose Self-Monitoring (CGM)**

A proposed alternative to intermittent SMBG is continuous glucose monitoring (CGM). CGM devices provide ongoing, real-time monitoring and recording of blood glucose levels by continuous measurement of interstitial fluid. Interstitial readings generally lag from three to 20 minutes behind finger-stick values. Since the CGM makes patients aware of previously undetectable elevations in glucose levels, the patient may administer insulin to often resulting in hypoglycemia. Over adjustment to alarms is also a hazard of these devices. Because of the lag time, CGM should only be used as an adjunct to SMBG to ascertain the overall blood glucose dynamics. The CGMS should never be used as a solo tool to manage or adjust the patient's therapy (Wolpert, 2008) (Hirsch, et al., 2008; Wolpert, 2008).

Some monitors require that a sensor be introduced into the abdominal wall (i.e., minimally invasive), while another option is a watch-type device worn on the wrist which abstracts fluid through the skin (i.e., noninvasive). The continuous glucose monitoring system (CGMS) consists of a sensor, transmitter and receiver. Some monitors provide real-time information, while others require that data be downloaded and reviewed retrospectively. Depending upon the device, a sensor may be worn for 3–7 days before it must be changed. Some devices provide a high/low glucose alarm. The objective for the use of CGMS is to obtain continuous information regarding shifting blood glucose levels. Ideally, this information would help the patient maintain a constant glucose level and minimize episodes of hypoglycemia and hyperglycemia, such as those seen at mealtime and during exercise.

CGM may be used by treating physicians as a one-time evaluation tool (i.e., 72-hour, three-day period) for type 1 and type 2 insulin-treated individuals who are experiencing hypo- or hyperglycemic episodes unresponsive to adjustments in therapy (e.g., insulin administration and nutrition). It may also be used to detect asymptomatic nocturnal hypoglycemia and for lowering HbA1c levels without risking severe hypoglycemia (Behrman, 2004). The 72-hour recording may identify fluctuations in blood glucose that were not detected by intermittent fingersticks, which are typically performed four times per day. The 72-hour data allows adjustments to be made in the therapeutic regimen (e.g., oral medication, insulin therapy, diet, exercise) to minimize glucose excursion.

Repeat 72-hour assessments may be needed periodically until the individual stabilizes and achieves ideal treatment targets (Inzucchi and Sherwin, 2007).

It has also been proposed that CGM be used on a long-term basis for the treatment of type 1 diabetics. The ADA and a recent clinical trial by the Juvenile Diabetes Research Foundation (JDRF) support the use of long-term CGM in type 1 diabetics age 25 years or older. The JDRF study and other clinical trials have demonstrated a reduction of up to 1.0% in the A1c level in this age group. It has been proposed that one of the reasons for better outcomes in older individuals is because they are typically more compliant in the use of CGM than adolescents and children. In individuals less than age 25 years, CGM has been shown to be effective in those who experience severe episodes of hypoglycemia with a blood glucose level < 50mg/dL not corrected by adjustments in conventional therapies (e.g., SMBG four or times per day, insulin therapy). Although the limited number of clinical trials with short-term follow-ups are lacking in strong, definitive conclusions, the evidence is suggestive of improved clinical outcomes including normalization of A1c levels and a reduction of hypoglycemic episodes. Professional societies and organizations (e.g., American Association of Clinical Endocrinologists [AACE], ADA and NICE) state that CGM may have a role in the ongoing assessment and management of this subgroup of type 1 diabetics.

Long-term use of CGM may also be indicated in a subgroup of type 2 diabetics who are producing minimal amounts of insulin (i.e., insulinopenia). One way to determine the insulin level in the body is by using a blood test called a connecting peptide (C-peptide) test. C-peptide is a polypeptide of 31 amino acids and a byproduct of insulin production. The level of C-peptide in the body reflects the amount of insulin being produced. Type 2 diabetics with an extremely low C-peptide level may be considered to have a “burned-out pancreas”, act like a type 1 diabetic, and benefit from an intense insulin regimen. Insulinopenia is diagnosed in less than 5% of type 2 diabetics. A fasting C-peptide level that is  $\leq$  110% of the lower limit of normal of the laboratory’s measurement method and a concurrently obtained fasting glucose of  $\leq$  225 milligrams/deciliter (mg/dL) is indicative of insulinopenic type 2 diabetes mellitus. In patients with compromised renal function, a creatinine clearance (actual or calculated from age, gender, weight and serum creatinine)  $\leq$  50 milliliters (mL)/minute, and a fasting C-peptide level that was  $\leq$  200% of the lower limit of normal of the laboratory’s measurement methods is indicative of insulinopenia. For example, if the laboratory normal C-peptide range was 0.78–1.89 nanograms/milliliter (ng/mL) then the insulinopenic type 2 diabetic without renal insufficiency would have a value of  $\leq$  0.86 ng/mL and with renal sufficiency would have a value of  $\leq$  1.56 ng/mL. This subset of individuals may be candidates for CGM (National Library of Medicine (NLM), 2008; Centers for Medicare and Medicaid [CMS], 2005; CMS, 2001).

**U.S. Food and Drug Administration (FDA):** Continuous glucose monitors require premarket approval (PMA) by the FDA. CGMS are used only as an adjunct to SMBG. They should never replace or be used instead of SMBG. Some monitors provide a sensor that records data for 72 hours and are intended for occasional rather than everyday use. Examples of these devices include the CGMS<sup>®</sup> System Gold<sup>™</sup> Continuous Glucose Monitoring System (Medtronic MiniMed, Inc., Northridge, CA) and the The DexCom<sup>™</sup> STS<sup>™</sup> Continuous Glucose Monitoring System (DexCom, Inc., San Diego, CA) (FDA, 2006; Medtronic MiniMed, 2008). Other monitors provide data for up to five to seven days, such as the FreeStyle Navigator<sup>®</sup> Continuous Glucose Monitoring System (Abbott Diabetes Care, Alameda, CA) and the DexCom STS-7 Continuous Glucose Monitoring System respectively (FDA, 2007; FDA 2008b).

**Literature Review – 72-Hour Continuous Glucose Monitoring:** The evidence in the peer-reviewed literature supports the use of 72-hour CGM when used in conjunction with SMBG to aid in the management of insulin dependent diabetics who are difficult to control and not achieving treatment targets. Studies including type 1 and type 2 adult and child diabetics have been in the form of randomized controlled trials (Yoo, et al., 2008; Deiss, et al., 2006a; Garge, et al., 2006; Larde, et al., 2006; Chico, et al., 2003; Ludvigsson, et al., 2003; Chase, et al., 2001), systematic review and meta-analysis (Chetty, et al., 2008; Golicki, et al., 2008), case series (Weber, et al., 2007; Zisser, et al., 2007) and retrospective review (Maia and Araújo, 2007). Patient populations ranged from 16 to 131 individuals with up to 3650 paired CGM/SMBG data sets. Follow-ups ranged from 12 weeks to six months. Even though some studies reported no significant differences with the use of CGM, most studies did report significant improvements in the time subjects spent hypoglycemic (< 55 mg/dL) and hyperglycemic (>240 mg/dL). Reductions in the number of nocturnal hypoglycemic events by up to 33% were also reported. Hypo- and hyperglycemic episodes were recorded during CGM that were unnoticed by the subjects. Some studies reported significant improvements in the A1c levels within groups, as well as between groups (CGM vs. SMBG). Maia and Araújo (2007) reported that the sensitivity and specificity of CGM in detecting hypoglycemia was

79.1% and 97.5%, respectively, normoglycemia 94.5% and 93.2%, respectively, and hyperglycemia 96.8% and 95.4%, respectively. Most reported adverse events were local irritation at the sensor insertion site (e.g., blister, bullae, edema and erythema). Hypoglycemic events occurred less often in individuals who had access to the data when displayed by the CGM and were typically minor events. In their study, Lagarde et al. (2006) reported that there were no adverse events, but there was a trend toward minor episodes of hypoglycemia during total CGM compared to the control group ( $p=0.24$ ). More severe events occurred in individuals who did not adhere to SMBG and/or medication regimens.

**Literature Review – Long-Term Continuous Glucose Monitoring in Adults:** Garg and Jovanovic (2006) conducted a study to evaluate the safety and efficacy of a seven-day abdominal, transcutaneous, real-time CGM (DexCom) in a heterogeneous group of insulin-requiring diabetics ( $n=86$ ). The study included type 1 ( $n=69$ ) and type 2 ( $n=17$ ) diabetics, age older than 18 years, from five centers. Forty-three patients used continuous insulin infusion, and 43 administered multiple daily insulin injections. SMBG was utilized in conjunction with CGM. Glucose trends at one, three and nine hours were recorded along with alerts for blood glucose levels  $> 200$  mg/dL (high),  $< 80$  mg/dL (low) and  $< 55$  mg/dL (hypoglycemic). There were 6811 paired points collected, of which 6334, between 40–400 mg/dL, were analyzed. Data was blinded during period one (i.e., seven days) and unblinded during periods two and three (i.e., seven days each). Data analysis was conducted based upon baseline A1c values (i.e.,  $A1c \leq 6$ , 6–7, 7–8, 8–9, 9–10, and  $> 10\%$ ). The  $A1c > 10\%$  group recorded substantially lower middle of the day values compared to night and early morning hours and recorded improvement at all hours of the day. In blinded subjects, only the  $A1c \leq 6\%$  group experienced average normal glucose levels between midnight and 7:00 a.m. Compared to the control period, overall average time spent between 81–141 mg/dL increased by 1.4 hours per day during unblinded time ( $p < 0.0001$ ). Time spent at  $< 55$  mg/dL decreased an average of 0.3 hours per day ( $p=0.0039$ ), and the time spent at  $< 240$  mg/dL was reduced an average of 1.5 hours per day ( $p < 0.0001$ ). The greatest improvements were observed in patients with higher A1c baseline values. The  $A1c \leq 6\%$  group demonstrated midday peaks but essentially normal levels the rest of the day, with the opposite being seen in the  $A1c > 10\%$  group. The overall population increased their time spent in euglycemia, and reduced the time spent in hypoglycemia and hyperglycemia. Reported side effects included erythema and ecchymosis at the sensor site of insertion, as well as erythema, edema and ecchymosis secondary to sensor adhesive.

To study the effects of real-time continuous glucose monitoring, Bailey et al. (2007) conducted a 12-week observational study of A1c levels in type 1 and type 2 diabetics, age range 31–59 years, who used multiple daily insulin injections ( $n=57$ ), continuous insulin infusion ( $n=75$ ) or oral agents ( $n=7$ ). A1c was measured at baseline, week six and week 12 with three-week interval follow-up visits for resupply of materials, documentation of adverse events and data downloading. CGM (DexCom) was used continuously as an adjunct to SMBG fingersticks to make diabetes-related decisions such as adjustment in insulin dosage. Patients were divided into three subgroups—those with a baseline A1c  $< 7\%$ , 7.0–9.0% and  $> 9\%$ . Patients with a baseline A1c of 7.0–9.0% lowered their values by  $0.5 \pm 0.06\%$ . Those with an A1c baseline  $> 9.0\%$  demonstrated a reduction of  $1.4 \pm 0.4\%$ . Quantification of CGM attention revealed that patients in the top quartile of CGM attention experienced a greater A1c reduction compared to those in the bottom quartile ( $p < 0.05$ ). Adverse events included five hypoglycemic events which were proposed as not related to CGM. Patients did not report an increase in the time spent with a glucose level of  $< 70$  mg/dL. Overall, at the end of the 12-week study, the A1c was reduced by  $0.4 \pm 0.05\%$  ( $p < 0.0001$ ). Most reductions occurred during the first six weeks and were maintained to week 12. The authors noted that a limitation of the study was the lack of a control group, which meant that a “causal link between CGM use and HbA1c reduction” could not be proven, and suggested that a large randomized control trial was indicated.

Weinstein et al. (2007) conducted a study to compare the accuracy of the Freestyle CGMS to measurements from venous blood. Type 1 diabetics ( $n=58$ ), ages 18–64 years, wore one CGMS sensor on the upper arm and a second sensor on the abdomen. Glucose levels were checked by finger stick every 15 minutes for 50 hours over a five-day period. Sensor accuracy was the highest during euglycemia and hyperglycemia. There were a total of 20,362 paired points. Compared to venous results, the FreeStyle mean and median absolute relative differences were 12.8 and 9.3%, respectively and 82.5% in the clinically accurate Clarke error grid A zone on day one and 80.9% on day five.

Garg et al. (2007) studied glucose control and its relationship to glucose target ranges using continuous CGM ( $n=24$ ) for six days. Baseline and 12-week A1c values were recorded. Downloading of CGM (DexCom) data

occurred at baseline, six and 12 weeks. A 0.4% improvement in A1c was observed and the authors noted that this change was “most likely due to behavioral changes”.

Using ambulatory glucose profiles, Mazze et al. (2008) compared glucose measures (e.g., A1c, total area under the curve, percentiles and durations) of types 1 (n=15) and 2 diabetics (n=15), age range 31–57 years, to healthy subjects (n=32) using the FreeStyle CGMS. The CGMS was utilized 24–32 days averaging 33–125 readings per day. The FreeStyle device reported 58–92% of expected values with data loss due to sensor/receiver initialization failure, calibration error and lack of adherence to protocol. Compared to the healthy subjects, the CGMS group were significantly higher in all glycemc measures ( $p < 0.001$ ) except for “percentage of hypoglycemia (CGM  $< 70$  mg/dL) episodes for type 2 diabetes (2.9%) compared to 2.7%” for healthy subjects. Healthy subjects and type 2 diabetics had similar percentages of hypoglycemia (2.7 vs. 2.9%), compared to type 1 diabetics who had significantly more episodes (7.1%). The duration of hypoglycemic episodes averaged 36 minutes in healthy adults and 72 minutes in diabetics.

**Literature Review – Long-Term Continuous Glucose Monitoring in Children:** Hypoglycemia in children is the most feared complication in diabetes and is especially worrisome for children and parents, especially nocturnal hypoglycemia. Hypoglycemia can be a significant impediment to metabolic control because it is less likely to be recognized. CGMS is proposed to have the capability of identifying hypoglycemic episodes (Wiltshire, et al., 2006).

In a controlled crossover trial, Ludvigsson et al. (2003) reported improved glycemc control in type 1 pediatric patients (mean age 12.5, n=27). The trial evaluated MiniMed CGMS as an adjunct to SMBG for improved glycemc control. All patients underwent CGM for three days every other week for 24 weeks as an adjunct to SMBG  $\geq 2$  times per day. Patients were randomized to CGM data available for 12 weeks with crossover to data unavailable for 12 weeks. Once per week, patients underwent seven SMBG readings, and CGM was calibrated with SMBG readings. A1c levels decreased in the open arm from 7.70% to 7.31% but not in the blind arm (7.75% to 7.65%). Twenty-six patients experienced daytime low blood glucose, and all of the patients had at least one nocturnal low blood glucose level.

Deiss et al. (2006a) conducted a double-blinded, cross-over randomized trial to “study the feasibility and influence on glycemc control” of CGMS (Medtronic MiniMed) for type 1, insulin-dependent diabetic children, age range 2.3–16.3 years. During the first 12 weeks, group A (n=15) had access to the CGMS data while group B (n=15) was blinded to the CGMS data. SMBG was also performed by both groups at least five times per day and as needed for suspected hypoglycemic events. At the onset of the study, at three and six months, 72-hour CGMS data were downloaded and insulin dosage adjustments were made as indicated. At the end of three months, the groups crossed over. The mean baseline A1c for group A was  $7.8 \pm 1.2\%$  vs. group B at  $8.4 \pm 1.1\%$  ( $p=0.148$ ). The mean three-month A1c for group A and B was  $7.8 \pm 1.1\%$  vs.  $8.3 \pm 1.1\%$  ( $p=0.233$ ), and the six-month A1c was  $7.6 \pm 1.1\%$  vs.  $8.5 \pm 0.9\%$  ( $p=0.026$ ), respectively. Average 24-hour hyperglycemc and hypoglycemc indicators were similar between the two groups. At three months, average glucose during the night was lower in group A ( $p=0.065$ ). No significant differences were seen in A1c between the two groups at 24 weeks ( $p > 0.10$ ), but A1c was lower in group B ( $p=0.026$ ). Insulin therapy was not different between the two groups ( $p > 0.10$ ). Whether blinded or not, no significant changes in A1c were seen in either arm (a,  $p=0.182$ ; b,  $p=0.823$ ). The authors noted that the selection process of study participants, chosen randomly and independent of glycemc problems, may have resulted in a “normal” population in whom CGM did not provide more relevant and effective information than SMBG.

Lagarde et al. (2006) conducted a six-month, single-blinded, randomized controlled trial including 27 insulin-dependent, type 1 diabetic children, age range 7–17 years, recruited from a hospital clinic to participate in the study. The objective was to determine if CGM (Medtronic MiniMed) could improve metabolic control in insulin-dependent, type 1 diabetics. The children were randomized to either the study group (n=18) or the control group (n=9). Each group engaged in 72-hour CGM upon entry into the study and at two and four months. The control group also conducted SMBG. Baseline A1cs were  $8.4 \pm 0.98$  and  $8.8 \pm 0.86\%$  for the study group and the control group, respectively ( $p=0.12$ ). At the end of the six months, A1c values included  $7.8 \pm 0.88$  vs.  $8.6 \pm 0.95\%$  for the study group and the control group, respectively ( $p=0.02$ ). The study group experienced a decrease of  $0.61 \pm 0.68\%$  ( $p=0.03$ ) in the A1c levels. The decrease in A1c for the control group was  $0.28 \pm 0.78\%$ , not statistically significant. The differences in the A1cs between the groups were not statistically significant ( $p=0.13$ ). There were no adverse events, but there was a trend toward minor episodes of

hypoglycemia during total CGM in the study group compared to the control group ( $p=0.24$ ). Limitations of the study include the small patient population, short-term follow-up, and the variation in the ages ( $p=0.0012$ ).

The Diabetes Research in Children Network [DirecNet] Study Group (2007) conducted a study to evaluate the use of the FreeStyle GMS in type 1 diabetic children. Results of the CGMS for the initial four to seven days were masked in order to obtain baseline values. Thereafter, the CGMS was used for 13 continuous weeks by the subjects. Usage dropped from 149 hours/week to 134 hours/week ( $p=0.006$ ) by the ninth week. Mean A1c was 7.1% at baseline compared to 6.8% at the end of 13 weeks ( $p=0.02$ ). Glucose values (71–180 mg/dL) increased from 52% to 60% ( $p=0.01$ ).

Wilson et al. (2007) compared the results of the FreeStyle CGMS to serum glucose values in 30 type 1 diabetic children, ages 3–18 years. An initial one week blinded period was conducted at home when glucose values could not be seen by the patient/parent. The initial week was followed by a 24-hour hospital admission to compare the CGMS results to serum glucose levels. Thereafter, the children used the CGMS at home for 13 weeks. The first two weeks at home, SMBG was conducted when the system alarmed. Beginning in the third week SMBG was left to the discretion of the patient and parent. There were 1811 inpatient paired values and 8639 outpatient paired values available for analysis. For the inpatient pairs, the median absolute difference was 17 mg/dL and the relative absolute difference was 14% compared to 20 mg/dL and 14%, respectively for the outpatient pairs.

Weinzimer et al. (2008b) conducted a study to evaluate the tolerance of the FreeStyle CGMS by 27 type 1 diabetic children, ages 4–17 years, who were being treated with multiple-dose insulin injections. Following an average use of over 100 hours a week for three months ( $n=23$ ), a significant reduction in the mean A1c level was reported ( $p=0.004$ ). The greatest reduction was seen in patients who had a baseline A1c level  $> 7.5\%$ . A significant reduction in mean glucose level was seen weeks one to four ( $p=0.003$ ) and remained constant thereafter. The authors noted that the results should be viewed with caution due to the lack of a control group and short-term follow-up.

**Literature Review – Long-Term Continuous Glucose Monitoring in Adults and Children:** Deiss et al. (2006b) conducted a study including 81 adults (age range 19–59.5 years) and 81 children (age range 8.0–18.9 years) with stable type 1 insulin-dependent diabetes, with an A1c  $\geq 8.1\%$ . Patients were randomized to either group 1, who used Guardian RT CGM continuously; group 2, who performed CGM biweekly for three-day periods every two weeks; or to the control group, who used SMBG. CGM patients performed SMBG prior to therapeutic intervention or corrective action for hypo- or hyperglycemia. Six patients did not complete the study. A reduction in A1c was seen in group 1 ( $0.6 \pm 0.8\%$ ) compared to the control group ( $0.2 \pm 0.8\%$ ) ( $p=0.008$ ) at one month and  $1.0 \pm 1.1\%$  vs.  $0.4 \pm 1.0\%$ , respectively, at three months ( $p=0.003$ ). There were no significant differences between group 1 and group 2. At the end of three months, 50% of group 1 patients experienced an A1c reduction of  $\geq 1\%$ , 37% of group 2 and 15% of group 3. A  $\geq 2\%$  reduction was seen in 26% of group 1 patients, 9% of group 2 patients and 4% of control group patients. A mean reduction in SMBG was recorded at one and three months in group 1, but was not statistically significant compared to groups 2 and 3. Even though almost all group 1 and 2 patients made adjustments in insulin dosage, dietary activities and/or lifestyle, average total insulin daily dosage was not significantly different compared to baseline dosage. One hypoglycemic episode was reported in one patient in group 1, which occurred despite corrective carbohydrate intake, and one episode occurred in group 2 when the CGM was not being utilized. The authors reported that the patients did not record specific information regarding daily self-management activities but reported that changes were made. Therefore, delineation between the link between CGM and improvement in glycemic control could not be made. They also stated that intermittent corrective adjustments of insulin dosage may have been made by individual patients.

Mastrototaro et al. (2008) retrospectively evaluated 60,050 paired data points obtained from the Medtronic RT-CGMS and from SMBG values of insulin-pump dependent type 1 diabetics, age range 12–80 years ( $n=52$  adults/47,611 paired values; 20 adolescents/12,439 paired values). CGM was performed at least 6 days per week for six months. SMBG was performed at least four times per day and as needed by all subjects. The CGMS users set their own high and low alerts. Overall 75.6% of CGM readings were within  $\pm 20\%$  and 86.8% were within  $\pm 30\%$  of SMBG. Adults were 76.8% within  $\pm 20\%$  and  $87.5 \pm 30\%$  and adolescents were 71.2% within  $\pm 20\%$  and 83.8% within  $\pm 30\%$ . The highest rate of agreement was within the 240–400 mg/dL range. The overall mean absolute relative difference (i.e., the average of absolute percentage difference of CGM and the time-matched SMGB value) was 15.8% (15.2% for adults and 18.0% for adolescents). The overall median

absolute relative difference was 10.9% (10.5% for adults and 12.4% for adolescents). The overall difference between the CGM and meter values (the bias) was -2.13 mg/dL (-2.0 mg/dL for adults and -3.4 mg/dL for adolescents).

In a randomized controlled trial, the Juvenile Diabetes Research Foundation (2008) evaluated the safety and efficacy of CGM in insulin-dependent type 1 diabetics (n=322). All subjects had a glycated hemoglobin level of 7–10% (the majority being in the 7–8% range) and had not used CGM for six months prior to study enrollment. An initial run-in phase in which all subjects wore a CGM for 6–7 days (blinded to results) and performed SMBG at least three times per day was required. Patients were randomly assigned to either CGM (n=165) or SMBG (n=157) (control group) and were further stratified according to age group (i.e.,  $\geq 25$  years [n=98]; 15–24 years [n=110]; and 8–14 years [n=114]) and glycated hemoglobin level (i.e.,  $\leq 8.0\%$  and  $> 8.0\%$ ). The CGM group used the device on a daily basis and verified the accuracy of the home glucose meter prior to making management decisions. The SMBG subjects were instructed to perform finger-sticks at least four times per day. The primary outcome was the change in the mean glycated hemoglobin level from baseline to 26 weeks. Secondary outcomes for glycated hemoglobin at 26 weeks included the following: a relative decrease of  $\geq 10\%$ ; a 26-week level of  $< 7\%$ ; an absolute decrease of  $\geq 0.5\%$ ; a relative increase of  $\geq 10\%$ ; and an absolute increase of  $\geq 0.5\%$ .

Follow-up visits occurred at weeks one, four, eight, 13, 19 and 26. Follow-up phone calls were conducted between visits to review data and adjust therapy as indicated. Following the 26-week visit, the glycated hemoglobin level was measured in all subjects and the SMBG groups wore a CGM for one week ensuring that 96 hours of data were recorded.

From baseline to 26 weeks, the authors noted a significant between-group difference in the mean glycated hemoglobin level in patients who were age  $\geq 25$  years in favor of the CGM group (mean difference in change -0.53%;  $p < 0.001$ ). Significant differences were not noted in the age 15–24 year group (mean difference in change 0.08;  $p = 0.52$ ) or the age 8–14 year group (mean difference in change -0.13;  $p = 0.29$ ). Regarding secondary outcomes, the age 15–24 year group experienced no significant differences in any values. However, compared to baseline, subjects in the CGM age 8–14 years group had significant changes in the following:

- relative decrease by  $\geq 10\%$  in glycated hemoglobin level ( $p = 0.04$ )
- absolute decrease by  $\geq 0.5\%$  in glycated hemoglobin level ( $p = 0.009$ )
- 26-week level glycated hemoglobin level  $< 7\%$  ( $p = 0.01$ )
- 26-week level glycated hemoglobin level  $< 7\%$  with no severe hypoglycemic events ( $p = 0.02$ ).

At the 26-week follow-up, the CGM age  $\geq 25$  years group demonstrated improvements in all measures of glycemic control when compared to the control group. Significant improvements were seen in the CGM values and were reported as follows:

- mean decrease in the glycated hemoglobin level ( $p < 0.0001$ )
- relative decrease by  $\geq 10\%$  in the glycated hemoglobin levels ( $p = 0.003$ )
- absolute decrease by  $\geq 0.5\%$  in glycated hemoglobin level ( $p < 0.001$ )
- 26-week level of glycated hemoglobin level  $< 7\%$  ( $p = 0.005$ )
- frequency of glycated hemoglobin levels  $< 7\%$  with absence of severe hypoglycemic event ( $p = 0.006$ )

The older CGM group had a significantly higher 6-day average sensor usage compared to the younger age groups (83% of age  $\geq 25$  years; 30% of age 15–24 years; 50% of age 8–14 years) ( $p < 0.001$ ). Data were used from the initial blinded run-in CGM phase and the 26-week CGM unblinded phase to estimate the amount of time spent each day hypoglycemic ( $\leq 70$  mg/dL or  $\leq 50$  mg/dL), hyperglycemic ( $> 180$  mg/dL or  $> 250$  mg/dL) or in the target range. There were no significant changes in the time spent in these ranges for the child and adolescent age groups. There was a significant improvement in time spent in each range by the adult group (71–180 mg/dL  $p < 0.001$ ;  $> 180$  mg/dL  $p = 0.002$ ;  $> 250$  mg/dL  $p < 0.001$ ).

Regarding generalizability of the results of the study, the authors noted the following: at the time of enrollment most of the patients had better than average glycated hemoglobin levels due to the use of intensive insulin therapy and frequent SMBG; prior to study enrollment, patients had to demonstrate the ability to insert and wear a sensor; the number of patients using MDI was too small to make a definitive assessment compared to CSII users. Although the study indicated that CGM may improve glycated hemoglobin level in adults with type 1 diabetes that have the “motivation to use this technology and the capability to incorporate it into their own daily

diabetes management”, further studies are needed to assess the effectiveness of CGM in the children and adolescents population.

The Canadian Coordinating Office for Health Technology Assessment (CCOHTA) states that CGMS may be beneficial to patients who have difficulty controlling blood glucose during initiation or monitoring of insulin pump use (CCOHTA, 2002).

The NICE states that CGMS in adults should be considered if “there is repeated hyper- or hypoglycemia at the same time of day, or hypoglycemia unawareness is unresponsive to conventional insulin dose adjustment” (NICE, Jul 2008c). For type 1 children and young adults NICE states that CGMS “should be offered” to children and young adults with persistent hypoglycemia unawareness or repeated hypo- or hyperglycemic episodes, but further research is needed to evaluate the routine use of CGMS (NICE, 2004).

The National Health Service Quality Improvement Scotland (NHS QIS) published an evidence note on the use of CGMS. They state that CGMS may be helpful when used with type 1 diabetics and type 2 diabetics on insulin. Limitations include measurement of interstitial glucose rather than capillary glucose and lack of real-time glucose level. Sudden temperature changes, excess perspiration and strong electromagnetic forces may interfere with CGMS function. They also state that there is a need for well-designed “adequately powered” randomized controlled trials to determine long-term outcomes and sustained benefit of glycemic control (NHS QIS, 2005).

**Literature Review - Continuous Glucose Monitoring in Pregnancy:** Management of diabetes during pregnancy (maternal diabetes) is essential for healthy outcomes for the mother and the infant. An individual with preexisting type 1 or type 2 diabetes mellitus may become pregnant or a woman can develop diabetes during the pregnancy (i.e., gestational diabetes). Gestational diabetes typically subsides following delivery. Uncontrolled diabetes during pregnancy can be associated with miscarriage, pre-eclampsia, preterm labor, stillbirth, congenital malformations and other complications. Both 72-hour and long-term CGM have been proposed for use during pregnancy (NICE, 2008b).

Kestilä et al. (2007) conducted a randomized controlled trial to compare CGM (n=36) to SMBG (n=37) in detecting patients with gestational diabetes mellitus (GDM) who needed antidiabetic drug treatment. High-risk pregnant women at 22–34 gestational weeks who had at least two abnormally high glucose values on oral glucose tolerance testing were included in the study. The mean CGM period was  $47.4 \pm 2.5$  hours. SMBG was performed at least five times per day. Treatment modalities were offered within five days of monitoring. As a result of CGMS, 11 women were treated with either oral agents or insulin compared to three patients in the SMBG group ( $p=0.0149$ ). Within the CGM group, SMBG values were compared to the CGM values, and five SMBG patients were identified with indication for antihyperglycemic treatment compared to 16 CGM patients.

McLachlan et al. (2007) conducted a 72-hour CGM (Medtronic MiniMed) study as a tool for medical decision-making (n=68) in pregnant women with diabetes. The CGM detected postprandial hyperglycemia that was not detected or was underestimated by SMBG. Compared to SMBG, 42 of 63 CGM studies provided additional information (e.g., postprandial elevation, hyperglycemia and hypoglycemia), more so in GDM and type 1 diabetics compared to type 2 diabetics. The authors noted that a limitation of the study was that all targeted women did not agree to participate.

Murphy et al. (2007) conducted an observational data analysis of a randomized controlled trial involving pregestational type 1 (n=40) or type 2 (n=17) diabetics to “examine the changes in glycemic excursions that occur during pregnancy”. The Gold Medtronic CGMS provided 180 continuous glucose profiles (16,111 hours of data for type 1; 4316 hours for type 2). An average of 358 hours of continuous data was reported over gestation. Compared to type 1 diabetics, type 2 diabetics spent 33% less time hyperglycemic during pregnancy ( $p=0.005$ ). There was no significant difference in the risk of nocturnal hypoglycemia between types 1 and 2 ( $p=0.2$ ). The amount of time spent euglycemic rose from 43% to 56% for type 1 and from 58% to 75% for type 2 diabetics ( $p<0.0001$ ) over gestation. The amount of time spent hypoglycemic did not change significantly, but type 1 diabetics spent more time hypoglycemic than type 2 diabetics. Mean blood glucose levels ( $p=0.009$ ) and mean A1c levels ( $p=0.001$ ) significantly decreased over gestation. No significant differences were seen between types 1 and 2 in these levels.

Murphy et al. (2008) conducted a randomized controlled trial to compare the outcomes of type 1 (n=46) and type 2 (n=25) diabetic women, age range 16–45 years, who used CGMS (n=38) compared to SMBG (n=33) during pregnancy. CGM was performed for up to seven days at 4–6 week intervals, between 8–32 weeks' gestation. Data were downloaded and reviewed during follow-up visits and, in correlation with SMBG values, adjustments were made to diet, exercise and insulin therapy as indicated. The CGMS was used 0–8 times, mean 4.2 times, with 80% of the women wearing the monitor at least once per trimester. No significant differences were found in the mean A1c level between the two groups prior to week 32, but the CGM group had a consistently lower A1c level. A significant difference in A1c was seen between 32–36 weeks' gestation with the CGMS group having a lower mean A1c (p=0.007). Although not statistically significant, the CGMS group had a trend toward reduced emergency caesareans (p=0.08). There was no significant difference in infant morbidity between the two groups. Compared with healthy singletons of women in the SMBG group (n=30), women in the CGMS group (n=32) had significantly decreased mean birth weight standard deviation scores (p=0.05) and median birth weight centiles (p=0.02). Thirteen infants in the CGMS group compared to 18 infants in the SMBG group were macrosomic (p=0.05). The study suggested that the use of CGMS during pregnancy was associated with third-trimester improved glycemic control, lower birth weights and reduced risk of macrosomia. Author-noted limitations of the study included: the health professionals were not blinded, the small patient population, women were predominantly of white European ethnicity, and “differences in the maternal characteristics with longer duration of diabetes in the intervention group”.

In their 2008 guidelines on the management of diabetes during pregnancy, NICE states that CGM has been proposed to help identify women in whom short-term postprandial peaks of glycemia are not detected by SMBG which may help reduce the incidence of adverse outcomes of pregnancy (e.g., fetal macrosomia, caesarean section and neonatal hypoglycemia) through adjustments in therapy. However, they state that there is a lack of evidence to assess the effectiveness of CGM in preconception or during pregnancy.

**Professional Societies/Organizations:** The ADA's 2009 standards of care for the treatment and management of diabetes mellitus include the following recommendations for CGM:

- “Continuous glucose monitoring (CGM) in conjunction with intensive insulin regimens can be a useful tool to lower A1C in selected adults (age ≥ 25 years) with type 1 diabetes.
- Although the evidence for A1C lowering is less strong in children, teens, and younger adults, CGM may be helpful in these groups. Success correlates with adherence to ongoing use of the device.
- Based upon expert consensus/clinical experience, CGM may be a supplemental tool to SMBG in those with hypoglycemia unawareness and/or frequent hypoglycemic episodes”.

They also list the initiation of CGM as a treatment option for individuals when treatment goals are not met.

In their guidelines for the management of diabetes, the American Association of Clinical Endocrinologists (AACE) lists CGMS as a clinical consideration for type 1 diabetics with unstable glucose control and patients who cannot achieve an acceptable HbA1c. They state that CGMS is “particularly valuable in detecting both unrecognized nocturnal hypoglycemia and postprandial hyperglycemia” (AACE, 2007).

### **Data Management Systems**

Although data management systems offer convenience in tracking test results and glucose levels, the ADA (2008a) states that the systems are not a necessity and a “well-kept, handwritten logbook may provide all the information necessary.” Disadvantages of these systems include the complexity, time and labor intensiveness of downloading the data (Laffel, et al., 2006). There is insufficient evidence in the peer-reviewed literature to support that data management systems improve diabetic management or health-care outcomes.

Laffel et al. (2007) conducted a randomized controlled trial (n=205) to evaluate glycemic control in insulin-treated patients who utilized an integrated glucose meter and electronic logbook compared to patients who used a conventional glucose meter and paper logbook. Type 1 and type 2 adult and pediatric patients (n=70) were recruited from seven centers to participate in the study. Participants were either using continuous insulin infusion or multiple daily injections of insulin, performing SMBG two or more times a day, and had an A1c ≥ 8% with stable glycemic control. During the first four weeks, all patients used their glucose monitor and written logbooks. At week four, patients were randomized to either a glucose monitor and written logs (i.e., paper group) (n=92) or to an integrated glucose meter/logbook (i.e., electronic group) (n=113). Follow-up visits occurred at four, eight, 12, 16 and 20 weeks. Upon completion of the study, mean A1c decreased -0.27% in the

paper group compared to -0.35% in the electronic group ( $p=0.022$ ). Pediatric patients also demonstrated similar results ( $p=0.024$ ). The electronic group reported performing more average daily SMBG checks than the paper group ( $p=0.03$ ). There was no significant difference in the mean amplitude of glycemic excursion between the two groups, but the rate of reported hypoglycemic events was lower in the paper group ( $p<0.0001$ ). A total of 104 patients were available for a follow-up visit at 66 weeks, and patients were identified by four subgroups (i.e., group 1a had continued with meter/paper log since the 20-week visit; group 1b switched to integrated meter/electronic log; group 2a continued with integrated meter/electronic log; and group 2b switched to meter/paper log). Between the four-week follow-up visit and the 66-week follow-up visit, mean A1c decreased significantly in those who continued using the electronic logbook ( $p=0.008$ ) compared to the other three subgroups who experienced an increase. A1c levels returned to the pre-trial level in these three groups. There was a statistically significant difference in mean A1c in those who used paper logbooks the entire time compared to those who used the electronic logbooks ( $p=0.006$ ). The same trend was seen among the pediatric patients ( $p=0.053$ ). From the last study visit to the 66-week visit, A1c increased in all groups. Limitations noted by the authors included short-term follow-up, neither patients or providers could be fully blinded, the “greater reduction in A1c in the electronic group may have yielded a greater number of measured hypoglycemic episodes,” the increased recognition of hypoglycemic episodes in the electronic users may have resulted from more frequent monitoring and detection of events, and the choice of switching was made by the patient and provider. The authors noted that, although significant, the differences between the two study groups from the end of the RCT and the absolute reductions in A1c were modest and stated that additional studies were needed to confirm the outcomes of this study.

### **Alternative Site Testing**

Several monitors are available that allow alternative site testing (AST) allowing the blood sample to be drawn from other sites that are less sensitive than fingertips. The blood glucose values obtained from these sites may differ from those obtained from the finger especially at certain times of the day (e.g., after a meal). Alternate sites include fleshy parts of the hand (i.e., thenar), upper arm, thigh, or calf. Not all alternative site testing meters are FDA approval for each site. Some alternate site information states that AST should only be done if the patient has stable glucose levels. Other devices obtain glucose measurements from interstitial fluid (ISF) using various techniques. One technique involves reverse iontophoresis in which an electrical current is used to draw ISF, along with glucose, to the surface of the skin to be collected and tested. Another method involves use of a laser to create micropores in the dead layer of the skin from which ISF can be drawn allowing the glucose level to be read using an adhesive patch. Most of these devices are not intended to replace finger-stick SMBG and abnormal readings should also be verified using a blood glucose monitor (ECRI, 2008).

There are a number of concerns about AST monitors. It may be more difficult to start and stop the bleeding with this process than with the fingerstick. Alternate site blood glucose monitors may induce bruising, and may put diabetic patients at risk for infection due to decreased blood flow. The FDA (2004) stated that further research is needed to better understand the differences in test values between readings of AST monitors and fingerstick type monitors, as well as discrepancies’ possible impact on the health of diabetic patients. The FDA recommends fingerstick blood glucose checks when the individual has just taken insulin, is not typically aware of their hypoglycemic symptoms, has just eaten or exercised, is ill or under stress (FDA, 2008a). The ADA states that alternate site testing may be used when an individual’s blood glucose is not changing (e.g., before a meal). However, because “measurements taken from the fingertips reflect your “real time” glucose levels, whereas the glucose levels in alternate sites take 20 to 30 minutes to catch up” finger stick testing should be used after a meal, or during a hypoglycemic episode (ADA, 2008a). Insufficient evidence exists in the peer-reviewed literature to support the safety and efficacy of AST monitors.

**U.S. Food and Drug Administration (FDA):** Many FDA-approved glucose monitors include AST capability. Examples of AST monitors include: ACCU-CHEK<sup>®</sup> Aviva system (Roche Diagnostics) which can analyze blood samples from the palm, forearm, upper arm, thigh, or calf; and the Easy Check TD-4231 (TaiDoc Technology Corporation, San Chung, Taipei, TW) which can be used to test blood samples from the palm, the forearm, the upper arm, the calf and the thigh.

**Literature Review:** Lucidarme et al. (2005) conducted a study with 29 children, age range 5–17 years, with type 1 diabetes for at least one year, who performed SMBG  $\geq 3$  times per day. Patients were randomized to two consecutive eight-day periods during which two sampling sites were used, the thenar and the forearm. At the end of the 16-day period, patients were allowed to choose between fingertip and AST for a month and were then asked if AST was better. Fingertip testing was more accurate than forearm during hypoglycemia. Sixty-six

percent of patients preferred AST at the end of the first 16 days, and, at the end of the study, 73% reported that AST was better. The authors reported that this is the first study of AST in children under real-life conditions. They concluded that thenar and forearm sampling were reliable, but the forearm should not be used during hypoglycemia or high-risk hypoglycemia conditions.

In their guidelines for the management of diabetes in type 1 adults, NICE (2008c) does not recommend the use of alternate site testing (i.e., sites other than the finger tips) as a “routine alternative to conventional self-blood glucose monitoring”.

### **GlucoWatch® G2™ Biographer**

The GlucoWatch® G2™ Biographer (Cygnus, Inc., Redwood, CA) is an FDA-approved CGMS that is worn on the wrist like a watch and takes noninvasive glucose measurements through the skin every 10 minutes for up to 13 hours at a time. It is approved for use in patients seven years and older. After a two-hour warm-up period and calibration, the GlucoWatch begins monitoring by producing an electrical current that pulls fluid from the skin and measures the glucose in the fluid. It has a high/low glucose alarm feature (FDA, 2002).

The overall evidence in the published peer-reviewed literature indicates that the GlucoWatch did not improve glycemic control or reduce the occurrence of hypoglycemic attacks. Use of the device was associated with skin irritation, edema, erythema, skipped readings, false alarms, and inaccurate results. Sweating, rapid skin temperature changes and the use of creams on the skin may interfere with the function of the device. The device is no longer being sold (Weinzimer, et al. 2008a; Ellis, et al., 2007; Klonoff, 2007). Chase et al. (2003) conducted a single-blinded, randomized controlled trial to evaluate the GlucoWatch CGM system as an adjunct to SMBG for improvement of glycemic control in children (mean age 11.9 years; n=40). All patients were asked to perform SMBG  $\geq 4$  times a day. The CGM-plus-SMBG group was asked to wear CGM sensors four times per week for twelve hours for three months. An alarm sounded during CGM for blood glucose  $\leq 70$  mg/dL. Alarms were verified by SMBG. Results suggested that in diabetic children, CGM improved glycemic control and detection of hypoglycemia, but the study was limited by small sample size, patient withdrawal, failure to use blinded CGM for the SMBG group to determine whether CGM reduces the incidence of symptomatic hypoglycemia, wide variation in number of CGM uses per week, and reasons for the variation. There was no controlled follow-up.

Chase et al. (2005) reported a multicenter randomized trial to assess whether use of the GlucoWatch G2 Biographer (GW2B) in addition to standard glucose monitoring lowers HbA1c and reduces hypoglycemia compared to standard glucose monitoring alone. Subjects (n=200), age 7–17 years, with type 1 diabetes were randomly assigned at five centers to standard glucose monitoring (usual care) or standard glucose monitoring plus GW2B use for six months. Study outcomes included HbA1c values obtained at six months and occurrence of severe hypoglycemia. The mean HbA1c at baseline was 8.0% in both groups. At six months, HbA1c was 7.9% in the usual care group and 8.1% in the GW2B group (95% CI for mean reduction in the GW2B group compared to the usual care group; p=0.15). A decrease in HbA1c of  $\geq 0.5\%$  was achieved in 21% of the usual care group and 28% of the GW2B group (p=0.29). Severe hypoglycemia events occurred in 7% of the GW2B group and in 2% of the usual care group (p=0.10). In the GW2B group, sensor use declined throughout the study from a mean value of 2.1 times per week in the first month to 1.5 times per week in the sixth month. Reasons given for declining use included skin irritation (76%), frequent skips (56%), excessive alarms (47%), and inaccurate readings (33 skin reactions and other problems led to decreasing sensor use over time).

### **Other Home Blood Glucose Monitors**

Some monitors combine a standard finger-stick blood glucose meter with non-medical devices and/or non-diabetic testing capabilities. Examples of these monitors include a finger-stick meter combined with a cellular telephone (e.g., GlucoPack™, HealthPia America Corp., Newark, NJ), a blood pressure monitor (e.g., Advocate DUO, Diabetic Supply of Suncoast, Taipei County, Taiwan), and a cholesterol screening analyzer (e.g., CardioChek PA Analyzer, Polymer Technology Systems, Inc. Indianapolis, IN). These devices are considered convenience items for the individual and not medically necessary in the treatment of diabetes mellitus.

### **Summary**

Self-monitoring of blood glucose (SMBG) is an integral component of diabetes management, provided that the patient or caregiver is given instruction in technique and is capable of using the data to adjust therapy. While conventional monitors are adequate for most individuals, continuous self-monitoring of glucose is appropriate for a carefully selected subset of individuals.

The use of data management systems has not been shown to improve health-care outcomes. There is insufficient evidence in the peer-reviewed literature to support the safety and efficacy of alternative site testing (AST) blood glucose monitors and the GlucoWatch® G2™ Biographer. Finger-stick blood glucose monitors combined with non-medical devices or non-diabetes related testing capabilities are considered a convenience and not medically necessary in the treatment of diabetes mellitus.

## Coding/Billing Information

**Note:** This list of codes may not be all-inclusive.

**Covered when medically necessary:**

<b>CPT®*</b> <b>Codes</b>	<b>Description</b>
95250	Ambulatory continuous glucose monitoring of interstitial tissue fluid via a subcutaneous sensor for a minimum of 72 hours; sensor placement, hook-up, calibration of monitor, patient training, removal of sensor, and printout of recording
95251	Ambulatory continuous glucose monitoring of interstitial tissue fluid via a subcutaneous sensor for a minimum 72 hours; physician interpretation and report

<b>HCPCS</b> <b>Codes</b>	<b>Description</b>
A9276	Sensor; invasive (e.g., subcutaneous), disposable, for use with interstitial continuous glucose monitoring system, 1 unit = 1 day supply
A9277	Transmitter; external, for use with interstitial continuous glucose monitoring system
A9278	Receiver (monitor); external, for use with interstitial continuous glucose monitoring system
E0607	Home blood glucose monitor
E2100	Blood glucose monitor with integrated voice synthesizer
E2101	Blood glucose monitor with integrated lancing/blood sample
S1030	Continuous noninvasive glucose monitoring device, purchase (for physician interpretation of data, use CPT code)
S1031	Continuous noninvasive glucose monitoring device, rental, including sensor, sensor replacement, and download to monitor (for physician interpretation of data, use CPT code)

<b>ICD-9-CM</b> <b>Diagnosis</b> <b>Codes</b>	<b>Description</b>
250.00- 250.93	Diabetes mellitus
648.00- 648.04	Maternal diabetes mellitus, complicating pregnancy, childbirth, or the puerperium
648.80- 648.84	Gestational diabetes

\*Current Procedural Terminology (CPT®) © 2008 American Medical Association: Chicago, IL.

## References

1. AACE Diabetes Mellitus Clinical Practice Guidelines Task Force. medical guidelines for clinical practice for the management of diabetes mellitus. *Endocr Pract.* 2007 May-Jun;13 Suppl 1:1-68.
2. Agency for Healthcare Research and Quality (AHRQ). Applicability of the evidence regarding intensive Glycemic control and self-monitored blood glucose to medicare patients with type 2 diabetes. Sep 10, 2007. Accessed Jan 27, 2009. Available at URL address: <http://www.ahrq.gov/clinic/techix.htm>
3. American Diabetes Association (ADA). Clinical practice recommendations 2009a. Accessed Jan 8, 2009. Available at URL address: [http://care.diabetesjournals.org/content/vol32/Supplement\\_1/](http://care.diabetesjournals.org/content/vol32/Supplement_1/)
4. American Diabetes Association (ADA). Diabetes Forecast. 2009b resource guide. Accessed Jan 23, 2009. Available at URL address: <http://www.forecast.diabetes.org/magazine/resource-guide/2009-resource-guide>
5. American Diabetes Association (ADA). 2008 Resource Guide. A supplement to diabetes forecast 2008a. Accessed Jan 23, 2009. Available at URL address: <http://www.diabetes.org/diabetes-forecast/resource-guide.jsp>
6. American Diabetes Association (ADA). Clinical practice recommendations 2008. *Diabetes Care.* January 2008b, Volume 31, Supplement 1. Accessed Jan 26, 2009. Available at URL address: [http://care.diabetesjournals.org/content/vol31/suppl\\_1/](http://care.diabetesjournals.org/content/vol31/suppl_1/)
7. American Diabetes Association (ADA). Clinical practice recommendations. 2007. Accessed Jan 26, 2009. Available at URL address: [http://care.diabetesjournals.org/content/vol30/suppl\\_1/](http://care.diabetesjournals.org/content/vol30/suppl_1/)
8. American Diabetes Association (ADA). Standards of medical care in diabetes-2007. Jan 2007. Accessed Jan 26, 2009. Available at URL address: [http://care.diabetesjournals.org/cgi/reprint/30/suppl\\_1/S4](http://care.diabetesjournals.org/cgi/reprint/30/suppl_1/S4)
9. American Diabetes Association (ADA). Diabetes information. Standards of medical care in diabetes-2006. Jan 2006. Accessed Jan 26, 2009. Available at URL address: [http://care.diabetesjournals.org/cgi/reprint/29/suppl\\_1/s4](http://care.diabetesjournals.org/cgi/reprint/29/suppl_1/s4)
10. American Diabetes Association. Resource guide 2006. Blood glucose meters and data management systems. Accessed Jan 26, 2009. Available at URL address: [http://www.diabetes.org/uedocuments/rg06\\_meters.pdf](http://www.diabetes.org/uedocuments/rg06_meters.pdf)
11. American Diabetes Association (ADA). Diabetes information. Standards of care. 2005. Accessed Jan 26, 2009. Available at URL address: [http://care.diabetesjournals.org/content/vol28/suppl\\_1/](http://care.diabetesjournals.org/content/vol28/suppl_1/)
12. American Diabetes Association (ADA). Standards of medical care for patients with diabetes mellitus. *Dia Care.* 2003 Jan;26S:S33-S49.
13. American Diabetes Association (ADA). Third-party reimbursement for diabetes care, self-management education, and supplies. *Clinical Diabetes.* 2003 Nov;21:183-4.
14. American Diabetes Association (ADA). Blood glucose monitors and data management systems. Resource guide 2005. Accessed Jan 26, 2009. Available at URL address: <http://www.diabetes.org/rg2005/meters.jsp#dms>
15. Bailey TS, Zisser HC, Garg SK. Reduction in hemoglobin A1C with real-time continuous glucose monitoring: results from a 12-week observational study. *Diabetes Technol Ther.* 2007 Jun;9(3):203-10.
16. Behrman RE, Kliegman RM, Jenson HB. 583.2 Type 1 diabetes mellitus (immune mediated) monitoring. In: Behrman: *Nelson Textbook of Pediatrics*, 17th ed. Philadelphia: Saunders: 2004.
17. Bode B, Silver M, Weiss R, Martin K. Evaluation of a continuous glucose monitoring system for home-use conditions. *Manag Care.* 2008 Aug;17(8):40-5.

18. Buckingham B, Caswell K, Wilson DM. Real-time continuous glucose monitoring. *Curr Opin Endocrinol Diabetes Obes.* 2007 Aug;14(4):288-95.
19. Buhling KJ, Winkel T, Wolf C, Kurzidim B, Mahmoudi M, Wohlfarth K, Wascher C, Schink T, Dudenhausen JW. Optimal timing for postprandial glucose measurement in pregnant women with diabetes and a non-diabetic pregnant population evaluated by the Continuous Glucose Monitoring System (CGMS). *J Perinat Med.* 2005;33(2):125-31.
20. Canadian Coordinating Office for Health Technology Assessment (CCHOTA). Issues in emerging health technologies. Continuous glucose monitoring in the management of diabetes mellitus. May 2002 (32).
21. Centers for Medicare and Medicaid (CMS). Decision memo for insulin pump: C-peptide levels as a criterion for use (CAG-00092N). May 11, 2001. Accessed Feb 4, 2009. Available at URL address: <http://www.cms.hhs.gov/transmittals/downloads/R27NCD.pdf>
22. Centers for Medicare and Medicaid (CMS). CMS Manual System. Pub. 100-03 Medicare national coverage determination. Transmittal 27. Feb 4, 2005. Insulin pumps: C-peptide levels as a criterion for use. Accessed Feb 4, 2009. Available at URL address: <http://www.cms.hhs.gov/mcd/viewdecisionmemo.asp?id=41>
23. Chase HP, Kim LM, Owen SL, MacKenzie TA, Klingensmith GJ, Murtfeldt R, Garg SK Continuous subcutaneous glucose monitoring in children with type 1 diabetes. *Pediatrics.* 2001; 107:222-6.
24. Chase HP, Roberts MD, Wightman C, Klingensmith G, Garg SK, Van Wyhe M, et al. Use of the GlucoWatch biographer in children with type 1 diabetes. *Pediatrics.* 2003 Apr;111(4 Pt 1):790-4.
25. Chase HP, Beck R, Tamborlane W, Buckingham B, Mauras N, Tsalikian E, et al. the diabetes research in children (DirectNet) study group. A randomized multicenter trial comparing the GlucoWatch Biographer with standard glucose monitoring in children with type 1 diabetes. *Diabetes Care.* 2005 May;28(5):1101-6.
26. Chetty VT, Almulla A, Oduyungbo A, Thabane L. The effect of continuous subcutaneous glucose monitoring (CGMS) versus intermittent whole blood finger-stick glucose monitoring (SBGM) on hemoglobin A1c (HBA1c) levels in Type I diabetic patients: a systematic review. *Diabetes Res Clin Pract.* 2008 Jul;81(1):79-87.
27. Chico A, Vida K, Rios P, Sutra M, No vials A. The continuous glucose monitoring system is useful for detecting unrecognized hypoglycemia inpatients with type 1 and type 2 diabetes but is not better than frequent capillary glucose measurements fir improving metabolic control. *Dia Care.* 2003 Apr;26(4):1153-7.
28. Children with diabetes. Continuous glucose sensors. Nov 28, 2009. Accessed Jan 26, 2009. Available at URL address: <http://www.childrenwithdiabetes.com/continuous.htm>
29. Deiss D, Hartmann R, Schmidt J, Kordonouri O. Results of a randomised controlled cross-over trial on the effect of continuous subcutaneous glucose monitoring (CGMS) on glycaemic control in children and adolescents with type 1 diabetes. *Exp Clin Endocrinol Diabetes.* 2006a Feb;114(2):63-7.
30. Deiss D, Bolinder J, Riveline JP, Battelino T, Bosi E, Tubiana-Rufi N, Kerr D, Phillip M. Improved glycemic control in poorly controlled patients with type 1 diabetes using real-time continuous glucose monitoring. *Diabetes Care.* 2006b Dec;29(12):2730-2.
31. Diabetes Control and Complications Trial (DCCT) Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med.* 1993;329:977-86.

32. Diabetes Research in Children Network (DirecNet) Study Group. The accuracy of the Guardian RT continuous glucose monitor in children with type 1 diabetes. *Diabetes Technol Ther*. 2008 Aug;10(4):266-72.
33. Diabetes Research in Children Network (DirecNet) Study Group, Buckingham B, Beck RW, Tamborlane WV, Xing D, Kollman C, Fiallo-Scharer R, Mauras N, Ruedy KJ, Tansey M, Weinzimer SA, Wysocki T. Continuous glucose monitoring in children with type 1 diabetes. *J Pediatr*. 2007 Oct;151(4):388-93, 393.e1-2. Epub 2007 Aug 24.
34. ECRI Institute. Healthcare product comparison system. Blood glucose monitors. Plymouth Meeting (PA): ECRI Institute; 2008a. Available at URL address: <http://www.ecri.org>.
35. ECRI Institute. Real-time continuous glucose monitoring. [Emerging Technology evidence report]. Plymouth Meeting (PA): ECRI Institute; 2008b Oct 16. Available at URL address: <http://www.ecri.org>.
36. Ellis SL, Bookout T, Garg SK, Izuora KE. Use of continuous glucose monitoring to improve diabetes mellitus management. *Endocrinol Metab Clin North Am*. Dec 2007; 36(Suppl 2); 46-68.
37. Fiallo-Scharer R; Diabetes Research in Children Network Study Group. Eight-point glucose testing versus the continuous glucose monitoring system in evaluation of glycemic control in type 1 diabetes. *J Clin Endocrinol Metab*. 2005 Jun;90(6):3387-91. Epub 2005 Mar 22.
38. Gandrud LM, Xing D, Kollman C, Block JM, Kunselman B, Wilson DM, Buckingham BA. The Medtronic Minimed Gold continuous glucose monitoring system: an effective means to discover hypo- and hyperglycemia in children under 7 years of age. *Diabetes Technol Ther*. 2007 Aug;9(4):307-16.
39. Garg S, Jovanovic L. Relationship of fasting and hourly blood glucose levels to HbA1c values: safety, accuracy, and improvements in glucose profiles obtained using a 7-day continuous glucose sensor. *Diabetes Care*. 2006 Dec;29(12):2644-9.
40. Garg SK, Kelly WC, Voelmle MK, Ritchie PJ, Gottlieb PA, McFann KK, Ellis SL. Continuous home monitoring of glucose: improved glycemic control with real-life use of continuous glucose sensors in adult subjects with type 1 diabetes. *Diabetes Care*. 2007 Dec;30(12):3023-5.
41. Garg S, Zisser H, Schwartz S, Bailey T, Kaplan R, Ellis S, Jovanovic L. Improvement in glycemic excursions with a transcutaneous, real-time continuous glucose sensor: a randomized controlled trial. *Diabetes Care*. 2006 Jan;29(1):44-50.
42. Golicki DT, Golicka D, Groele L, Pankowska E. Continuous Glucose Monitoring System in children with type 1 diabetes mellitus: a systematic review and meta-analysis. *Diabetologia*. 2008 Feb;51(2):233-40.
43. HAYES Alert™. Next Generation of Continuous Glucose Monitoring Systems. Lansdale PA: HAYES, Inc; ©2005 Winifred S. Hayes, Inc. volume VIII (6) Jan 2005.
44. HAYES Alert™. Glucowatch does not improve glycemic control in children with type I diabetes. Lansdale PA: HAYES, Inc; ©2005 Winifred S. Hayes, Inc. volume VIII (1) Jun 2005.
45. HAYES Medical Technology Directory™. Continuous Glucose Monitoring Systems. Lansdale PA: HAYES, Inc; ©2003 Winifred S. Hayes, Inc. 2003 Jun. Updated May 22, 2007.
46. Hayes Outlook™. Freestyle® Navigator for continuous glucose monitoring. Lansdale PA: HAYES, Inc; ©2006 Winifred S. Hayes, Inc. Sep 6, 2006.
47. Hayes Search and Summary™. MiniMed Paradigm® REAL-Time Insulin Pump and Continuous Glucose Monitoring System (Medtronic Diabetes) for insulin-dependent diabetes – updated. Aug 14, 2006. Lansdale PA: HAYES, Inc; ©2005 Winifred S. Hayes, Inc.

48. Hayes Update Search. Continuous glucose monitoring system. Lansdale PA: HAYES, Inc; ©2008 Winifred S. Hayes, Inc. May 12, 2008.
49. Hoi-Hansen T, Pedersen-Bjergaard U, Thorsteinsson B. Reproducibility and reliability of hypoglycaemic episodes recorded with Continuous Glucose Monitoring System (CGMS) in daily life. *Diabet Med*. 2005 Jul;22(7):858-62.
50. Inzucchi SE, Sherwin RS. Chapter 247 – Type 1 diabetes mellitus. In: Goldman: Cecil Medicine 23<sup>rd</sup> ed. St. Louis: Saunders, 2007
51. Institute for Clinical Improvement. Health care guideline. Diagnosis and management of type 2 diabetes mellitus in adults. Mar 2008. Accessed Jan 26, 2008. Available at URL address: <http://www.icsi.org/search.aspx?searchFor=diabetes>
52. Jadviscokova T, Fajkusova Z, Pallayova M, Luza J, Kuzmina G. Occurrence of adverse events due to continuous glucose monitoring. *Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub*. 2007 Dec;151(2):263-6.
53. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group, Tamborlane WV, Beck RW, Bode BW, Buckingham B, Chase HP, Clemons R, Fiallo-Scharer R, Fox LA, Gilliam LK, Hirsch IB, Huang ES, Kollman C, Kowalski AJ, Laffel L, Lawrence JM, Lee J, Mauras N, O'Grady M, Ruedy KJ, Tansey M, Tsalikian E, Weinzimer S, Wilson DM, Wolpert H, Wysocki T, Xing D. Continuous glucose monitoring and intensive treatment of type 1 diabetes. *N Engl J Med*. 2008 Oct 2;359(14):1464-76.
54. Kestilä KK, Ekblad UU, Rönnemaa T. Continuous glucose monitoring versus self-monitoring of blood glucose in the treatment of gestational diabetes mellitus. *Diabetes Res Clin Pract*. 2007 Aug;77(2):174-9. Epub 2007 Jan 16.
55. Kitzmiller JL, Block JM, Brown FM, Catalano PM, Conway DL, Coustan DR, Gunderson EP, Herman WH, Hoffman LD, Inturrisi M, Jovanovic LB, Kjos SI, Knopp RH, Montoro MN, Ogata ES, Paramsothy P, Reader DM, Rosenn BM, Thomas AM, Kirkman MS. Managing preexisting diabetes for pregnancy: summary of evidence and consensus recommendations for care. *Diabetes Care*. 2008 May;31(5):1060-79.
56. Klonoff DC. Chapter 21. Monitoring technologies-continuous glucose monitoring, biomarkers of glycemic control, artificial pancreas. May 10, 2007. Accessed Jan 26, 2009. Available at URL address: <http://www.mdtext.com/diabetes/diabetes12/diabetesframe12.htm>
57. Klonoff DC. Continuous glucose monitoring: roadmap for 21st century diabetes therapy. *Diabetes Care*. 2005 May;28(5):1231-9.
58. Klonoff, David C. MD, FACP Continuous Glucose Monitoring Technology Delivers Detailed Diabetes Data. *Point of Care: The Journal of Near-Patient Testing & Technology*. 5(3):105-111, September 2006.
59. Laffel LM, Hsu WC, McGill JB, Meneghini L, Volkening LK. Continued use of an integrated meter with electronic logbook maintains improvements in glycemic control beyond a randomized, controlled trial. *Diabetes Technol Ther*. 2007 Jun;9(3):254-64.
60. Lagarde WH, Barrows FP, Davenport ML, Kang M, Guess HA, Calikoglu AS. Continuous subcutaneous glucose monitoring in children with type 1 diabetes mellitus: a single-blind, randomized, controlled trial. *Pediatr Diabetes*. 2006 Jun;7(3):159-64.
61. Lucidarme N, Alberti C, Zaccaria I, Claude E, Tubiana-Rufi N. Alternate-site testing is reliable in children and adolescents with type 1 diabetes, except at the forearm for hypoglycemia detection. *Diabetes Care*. 2005 Mar;28(3):710-1.

62. Ludvigsson J, Hanas R. Continuous subcutaneous glucose monitoring improved metabolic control in pediatric patients with type 1 diabetes: a controlled crossover study. *Pediatrics*. 2003 May;111(5 Pt 1):933-8.
63. Mahoney J, Ellison J. Assessing the quality of glucose monitor studies: a critical evaluation of published reports. *Clin Chem*. 2007 Jun;53(6):1122-8. Epub 2007 May 3.
64. Maia FF, Araújo LR. Efficacy of continuous glucose monitoring system (CGMS) to detect postprandial hyperglycemia and unrecognized hypoglycemia in type 1 diabetic patients. *Diabetes Res Clin Pract*. 2007 Jan;75(1):30-4.
65. Mastrototaro J, Shin J, Marcus A, Suler G; STAR 1 Clinical Trial Investigators. The accuracy and efficacy of real-time continuous glucose monitoring sensor in patients with type 1 diabetes. *Diabetes Technol Ther*. 2008 Oct;10(5):385-90.
66. Mazze RS, Strock E, Wesley D, Borgman S, Morgan B, Bergenstal R, Cuddihy R. Characterizing glucose exposure for individuals with normal glucose tolerance using continuous glucose monitoring and ambulatory glucose profile analysis. *Diabetes Technol Ther*. 2008 Jun;10(3):149-59.
67. McLachlan K, Jenkins A, O'Neal D. The role of continuous glucose monitoring in clinical decision-making in diabetes in pregnancy. *Aust N Z J Obstet Gynaecol*. 2007 Jun;47(3):186-90.
68. Medtronic MiniMed. CGMS<sup>®</sup> System Gold<sup>™</sup>: Continuous Glucose Monitoring System fact sheet. 2009. Accessed Jan 26, 2009. Available at URL address: [http://wwwp.medtronic.com/Newsroom/LinkedItemDetails.do?itemId=1101852250097&itemType=fact\\_sheet&lang=en\\_US](http://wwwp.medtronic.com/Newsroom/LinkedItemDetails.do?itemId=1101852250097&itemType=fact_sheet&lang=en_US)
69. Monnier L, Colette C, Boegner C, Pham TC, Lapinski H, Boniface H. Continuous glucose monitoring in patients with type 2 diabetes: Why? When? Whom? *Diabetes Metab*. 2007 Sep;33(4):247-52. Epub 2007 Feb 21.
70. Murphy HR, Rayman G, Duffield K, Lewis KS, Kelly S, Johal B, Fowler D, Temple RC. Changes in the glycemic profiles of women with type 1 and type 2 diabetes during pregnancy. *Diabetes Care*. 2007 Nov;30(11):2785-91. Epub 2007 Jul 31.
71. Murphy HR, Rayman G, Lewis K, Kelly S, Johal B, Duffield K, Fowler D, Campbell PJ, Temple RC. Effectiveness of continuous glucose monitoring in pregnant women with diabetes: randomised clinical trial. *BMJ*. 2008 Sep 25;337:a1680.
72. National Health Service Quality Improvement Scotland (NHS QIS). Evidence note 8 – Jan 2005. Continuous glucose monitors in diabetes mellitus – the continuous glucose monitoring system (CGMS). Issues for health service planners and practitioners. Accessed Jan 23, 2009. Available at URL address: [http://www.nhshealthquality.org/nhsqis/files/evidence\\_note8.pdf](http://www.nhshealthquality.org/nhsqis/files/evidence_note8.pdf)
73. National Institute for Clinical Excellence (NICE). Quick reference guide. Type 1 diabetes: diagnosis and management of type 1 diabetes in adults. Jul 2004. Accessed Jan 23, 2009. Available at URL address: <http://www.nice.org.uk/guidance/index.jsp?action=byID&o=10944>
74. National Institute for Clinical Excellence (NICE). CG15 Type 1 diabetes in adults: Full guideline, main section. Updated Aug 22, 2008c. Accessed Jan 23, 2009. Available at URL address: <http://www.nice.org.uk/page.aspx?o=220927>
75. National Institute for Clinical Excellence (NICE). CG15 Type 1 diabetes in children, young people and adults: Full guideline. Jul 2004. Accessed Jan 23, 2009. Available at URL address: <http://www.nice.org.uk/Guidance/CG15>

76. National Institute for Health and Clinical Excellence (NICE). CG66 Diabetes - type 2 (update): full guideline. May 28, 2008a. Accessed Jan 23, 2009. Available at URL address: <http://www.nice.org.uk/guidance/index.jsp?action=download&o=40803>
77. National Institute for Health and Clinical Excellence (NICE). CG63 Diabetes in pregnancy: full guideline. Jul 2008b. Accessed Jan 26, 2009. Available at URL address: <http://www.nice.org.uk/guidance/index.jsp?action=byID&o=11946>
78. National Library of Medicine (NLM). Medical encyclopedia. Insulin C-peptide. Jun 17, 2008. Accessed Feb 4, 2009. Available at URL address: <http://www.nlm.nih.gov/medlineplus/ency/article/003701.htm>
79. Pavlovich-Davis S. Choosing blood glucose monitors. *Nurs Spectr (Fla Ed)* 2004 Nov 29:1-9.
80. Pickup J. Performance assessment of the Medtronic-MiniMed Continuous Glucose Monitoring System and its use for measurement of glycemic control in Type 1 diabetic subjects. *Diabet Med*. 2003 Dec;20(12):1012-5.
81. Pitzer K, Desai S, Dunn T, Edelman S, Jayalakshmi Y, Kennedy J, et al. Detection of hypoglycemia with the Glucowatch Biographer. *Diabetes Care* 2001;24(10):881-5).
82. Reach G. Continuous glucose monitoring and diabetes health outcomes: a critical appraisal. *Diabetes Technol Ther*. 2008 Apr;10(2):69-80.
83. Rigfing C, Wiedmeyer H, Little R, England j, Tennill A, Goldstein D. Defining the relationship between plasma glucose and HbA. *Diabetes Care* 2002;25(2):275 8.
84. Sarol JN Jr, Nicodemus NA Jr, Tan KM, Grava MB. Self-monitoring of blood glucose as part of a multi-component therapy among non-insulin requiring type 2 diabetes patients: a meta-analysis (1966-2004). *Curr Med Res Opin*. 2005 Feb;21(2):173-84.
85. Schutt M, Kern W, Krause U, Busch P, Dapp A, Grziwotz R, Mayer I, Rosenbauer J, Wagner C, Zimmermann A, Kerner W, Holl RW; DPV Initiative. Is the frequency of self-monitoring of blood glucose related to long-term metabolic control? Multicenter analysis including 24,500 patients from 191 centers in Germany and Austria. *Exp Clin Endocrinol Diabetes*. 2006 Jul;114(7):384-8.
86. Sherwin RS. Chapter 242 – diabetes mellitus. Continuous glucose monitoring. In: Goldman: Cecil Textbook of Medicine, 22nd ed. St. Louis: W. B. Saunders. 2004.
87. Soumerai S, Mah C, Zhang F, Adams A, Barton M, Fajitova V, Ross-Degnan D. Effects of health maintenance organization coverage of self-monitoring devices on diabetes self-care and glycemic control. *Arch Intern Med*. 2004 Mar;164(6):645-52.
88. Tubiana-Rufi N, Riveline JP, Dardari D. Real-time continuous glucose monitoring using Guardian<sup>®</sup> RT: from research to clinical practice. *Diabetes Metab*. 2007 Dec;33(6):415-20.
89. U.S. Food and Drug Administration (FDA). Glucose meters & diabetes management. Dec 06, 2004. Updated Jun 14, 2005. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/diabetes/glucose.html>
90. U.S. Food and Drug Administration (FDA). Summary of safety and effectiveness. Guardian RT. Jul 18, 2005. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/PDF/p980022s011b.pdf>
91. U.S. Food and Drug Administration (FDA). Office of In Vitro Diagnostic Device and Evaluation Safety (OVID). Home use tests – glucose. Feb 29, 2008a. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/oivd/homeuse-glucose.html>

92. U.S. Food and Drug Administration (FDA). Summary of safety and effectiveness DexCom™ STS™ Continuous Glucose Monitoring System. Mar 24, 2006. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/pdf5/p050012b.pdf>
93. U.S. Food and Drug Administration (FDA). New device approval. GlucoWatch G2 Biographer. Sep 4, 2002. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/mda/docs/p990026S008.html>
94. U.S. Food and Drug Administration (FDA). New device approval. STS-7 Continuous Glucose Monitoring System – P050012/s001. Jun 25, 2007. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/mda/docs/P050012S001.html>
95. U.S. Food and Drug Administration (FDA). STS-7 Continuous Glucose Monitoring System - P050012/S001. May 31, 2007. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/pdf5/p050012s001.html>
96. U.S. Food and Drug Administration (FDA). Summary of Safety and Effectiveness Data FreeStyle Navigator® Continuous Glucose Monitoring System. Mar 12, 2008b. Accessed Jan 26, 2009. Available at URL address: <http://www.fda.gov/cdrh/pdf5/p050020b.pdf>
97. United States Department of Veterans Affairs. National Center for Patient Safety. Glucometer hazard summary. Jan 9, 2008. Accessed Jan 26, 2009. Available at URL address: <http://www.patientsafety.gov/SafetyTopics/glucometers.html>
98. Weber KK, Lohmann T, Busch K, Donati-Hirsch I, Riel R. High frequency of unrecognized hypoglycaemias in patients with Type 2 diabetes is discovered by continuous glucose monitoring. *Exp Clin Endocrinol Diabetes*. 2007 Sep;115(8):491-4.
99. Weinstein RL, Schwartz SL, Brazg RL, Bugler JR, Peyser TA, McGarraugh GV. Accuracy of the 5-day FreeStyle Navigator Continuous Glucose Monitoring System: comparison with frequent laboratory reference measurements. *Diabetes Care*. 2007 May;30(5):1125-30. Epub 2007 Mar 2.
100. Weinzimer SA, Tamborlane WV. Sensor-augmented pump therapy in type 1 diabetes. *Curr Opin Endocrinol Diabetes Obes*. 2008a Apr;15(2):118-22.
101. Weinzimer S, Xing D, Tansey M, Fiallo-Scharer R, Mauras N, Wysocki T, Beck R, Tamborlane W, Ruedy K; Diabetes Research in Children Network (DirecNet) Study Group. FreeStyle navigator continuous glucose monitoring system use in children with type 1 diabetes using glargine-based multiple daily dose regimens: results of a pilot trial Diabetes Research in Children Network (DirecNet) Study Group. *Diabetes Care*. 2008b Mar;31(3):525-7.
102. Welschen LM, Bloemendal E, Nijpels G, Dekker JM, Heine RJ, Stalman WA, Bouter LM. Self-monitoring of blood glucose in patients with type 2 diabetes who are not using insulin: a systematic review. *Diabetes Care*. 2005 Jun;28(6):1510-7.
103. Wilson DM, Beck RW, Tamborlane WV, Dontchev MJ, Kollman C, Chase P, Fox LA, Ruedy KJ, Tsalikian E, Weinzimer SA; DirecNet Study Group. The accuracy of the FreeStyle Navigator continuous glucose monitoring system in children with type 1 diabetes. *Diabetes Care*. 2007 Jan;30(1):59-64.
104. Wiltshire EJ, Newton K, McTavish L. Unrecognised hypoglycaemia in children and adolescents with type 1 diabetes using the continuous glucose monitoring system: prevalence and contributors. *J Paediatr Child Health*. 2006 Dec;42(12):758-63.
105. Wolpert HA. The nuts and bolts of achieving end points with real-time continuous glucose monitoring. *Diabetes Care*. 2008 Feb;31 Suppl 2:S146-9.

106. Yoo HJ, An HG, Park SY, Ryu OH, Kim HY, Seo JA, Hong EG, Shin DH, Kim YH, Kim SG, Choi KM, Park IB, Yu JM, Baik SH. Use of a real time continuous glucose monitoring system as a motivational device for poorly controlled type 2 diabetes. *Diabetes Res Clin Pract.* 2008 Oct;82(1):73-9.

107. Zisser HC, Bevier WC, Jovanovic L. Restoring euglycemia in the Basal state using continuous glucose monitoring in subjects with type 1 diabetes mellitus. *Diabetes Technol Ther.* 2007 Dec;9(6):509-16.

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## Policy History

<b>Pre-Merger Organizations</b>	<b>Last Review Date</b>	<b>Policy Number</b>	<b>Title</b>
CIGNA HealthCare	9/15/2008	0106	Home Blood Glucose Monitors
Great-West Healthcare	6/21/2007	02.206.03	Continuous Glucose Monitoring (CGM) Systems

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Connecticut General Life Insurance Company has acquired the business of Great-West Healthcare from Great-West Life & Annuity Insurance Company (GWLA). Certain products continue to be provided by GWLA (Life, Accident and Disability, and Excess Loss). GWLA is not licensed to do business in New York. In New York, these products are sold by GWLA’s subsidiary, First Great-West Life & Annuity Insurance Company, White Plains, N.Y.