

Non-Invasive Wearable Sensors to Detect Onset of Hypoglycemia: A Scoping Review



APPLIED COGNITIVE ERGONOMICS LAB

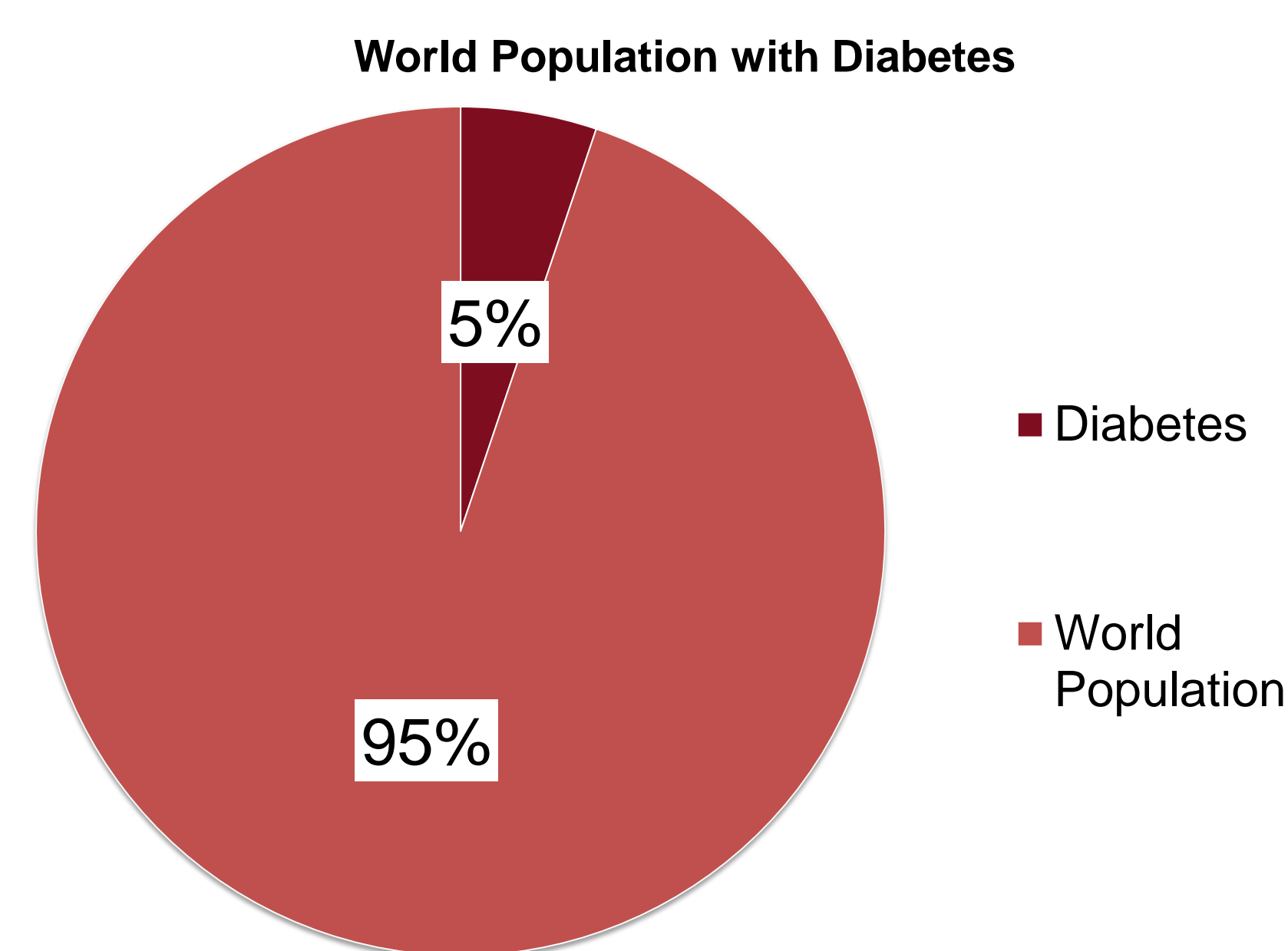
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1. Background

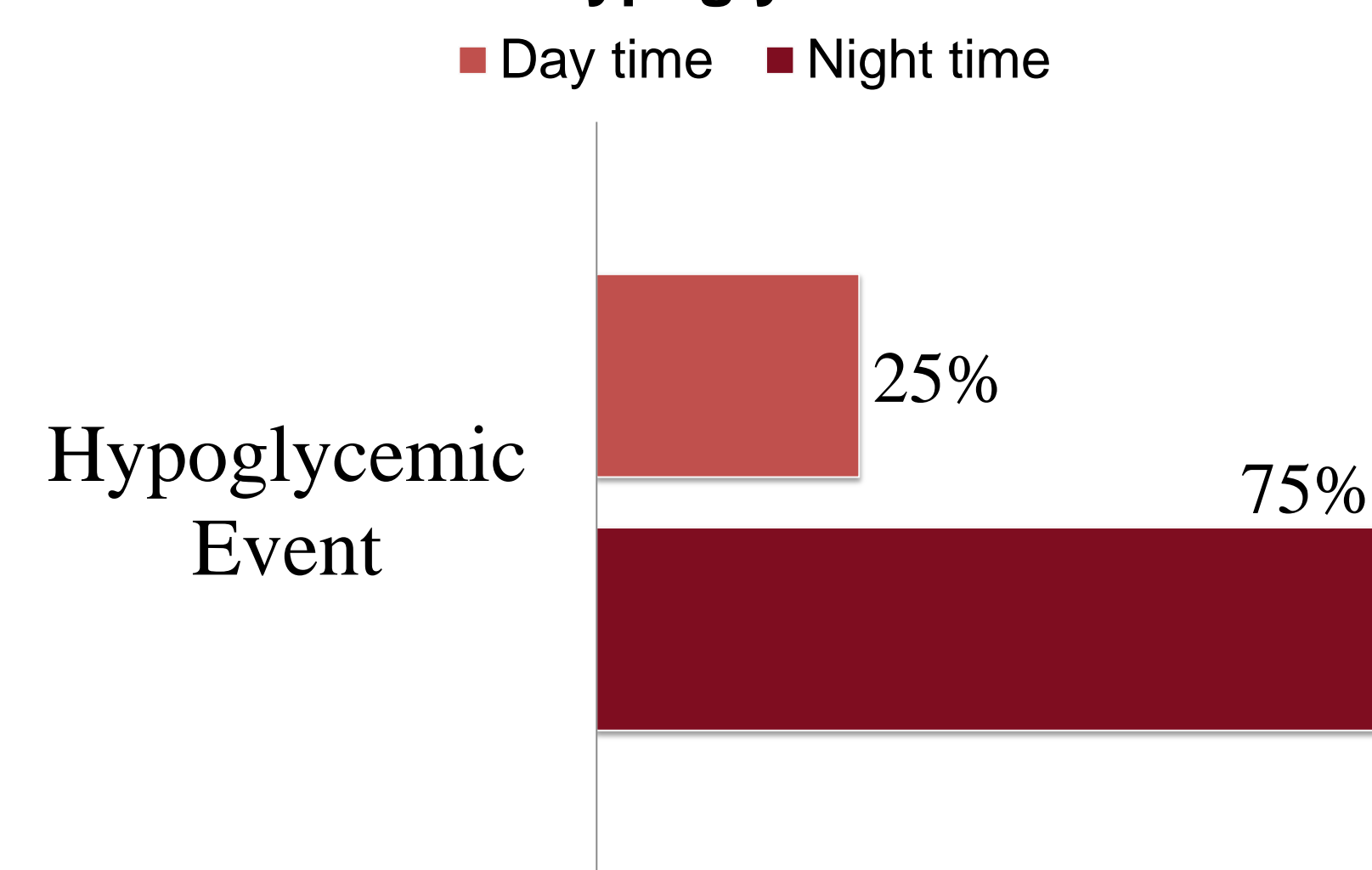
- Almost **460 million** people globally live with diabetes.



- Hypoglycemia is a dangerous condition that happens when the blood glucose level drops below 70mg/dL.

- Nocturnal Hypoglycemia is especially dangerous, patients can't wake up to regulate.

Time of Hypoglycemic Events



Continuous Glucose Monitoring devices (CGMs) are the most popular devices to monitor blood glucose and detect hypoglycemia:

Pros:

- Provides glycemc control
- Provides continuous monitoring
- Detects hypoglycemia

Cons:

- Expensive
- Accurate during the day, not so much at night
- Invasive
- Not prescribed for people with type 2 diabetes
- Requires frequent calibration and part change

2. Research Aims

Aim 1: Understand what physiological factors have been studied to detect hypoglycemia

Aim 2: Understand if tremors are a good indicator of hypoglycemia

Aim 3: Understand if any studies attempted to innovate a technology to detect hypoglycemic tremors

3. Methods, Results & Discussion

3.1 Scoping Literature Review on Tremors and Hypoglycemia

Methods :

- Used Texas A&M EBSCOHost research databases such as MEDLINE and Compendex on October 18, 2017
- 78 results, using keywords ["hypoglycemia"] and ["tremor" OR "trembling"]
 - Inclusion Criteria: Studies looking at non invasive technologies / Only studies published in English
 - 7 papers were found fitting the inclusion criteria

Results:

	Author	Year	Findings
1	Muhlhauser et al.	1991	17% of respondents reported tremors as their first symptom
2	Chiarelli et al.	1998	74% of children with diabetes surveyed said a frequent symptom they notice is trembling
3	Berlin et al.	2005	77% of respondents reported tremors as symptoms of hypoglycemia
4	Heller et al.	1987	Hypoglycemic patients had a noticeable increase in tremor readings (RMS) when BG dropped to 2.5mmol/L
5	George et al.	1995	Tremors did not become impaired like the responses of sweat and adrenaline
6	Schechter et al.	2012	Used a simplified measure of tremors as 1 of 4 symptoms to monitor onset of hypoglycemia
7	Rana & Chou	2015	Hypoglycemic tremor categorized as a medium frequency enhanced physiological tremor

3.2 Non Invasive Technologies

An additional search looked at ["hypoglycemia"] and ["non- invasive"] to survey the non invasive methods of detecting hypoglycemia

	Author	Year	Findings
1	Harris et al.	1996	Used 3 sensors to study the variations of pulse rates, humidity, and skin temperature around the wrist
2	Nguyen & Jones	2010	Alfa frequency of EEG Signals affected during hypoglycemia
3	Siegel, Lee, & Pikov	2014	Correlation between BG levels and millimeter wave absorption (MMW) was found with hypoglycemia
4	Yadav et al.	2015	Spectroscopy methods require more improvement in order to compete with popular CGMs on the market
5	Yotha et al.	2016	Monitored pulsatile changes in blood flow, internal pulse, body temp, and skin conductance
6	San, Ling, & Nguyen	2016	Longer QT intervals of ECG signals analyzed in order to detect hypoglycemic episodes
7	Zanon et al.	2017	A biosensor that has shown promise when tested on T1DM subjects
8	Howsmon & Bequette	2015	Exhaustive review of similar methods, concluded that sweat and body temperature are not accurate

3.3 Commercialized technologies



GlucoWatch G2®



GlucoWise™



HypoMon®



Diabetes Sentry

4. Discussion

- Hypoglycemic tremors:
 - Categorized as medium frequency enhanced physiological tremor
 - Not impaired with time
 - Common among diabetics
 - Signal can be analyzed using Actigraphy

- Hypoglycemic tremors seem worth studying.
- Other commercial technologies are very limited and have high false alarms

5. Work in Progress

- Currently, work is in progress to:
 - Design and test a wearable sensor that analyzes the tremor signals in real-time
 - Use Actigraphy to study the tremor signal
 - Develop a mobile application that
 - Communicates with the sensor
 - Provides extra features aimed at helping the patients manage their diabetes.

Most technologies have not been designed for usability and wearability, let alone user engagement

Common issues to consider in the design:

- Usability and ease of use
- Maintenance and calibration
- Recurring costs
- Wearability and non-obtrusiveness
- Data Processing V.S Battery Life
- Age and type of diabetic patients
- User engagement
- Optimal detection sensitivity

