The Environmental Implications and Mitigation of Discarded Hazardous Type 1 Diabetes Technology

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Background

- Type 1 Diabetes (T1D)
- Causes
- Climate change and diabetes
- Single-use medical waste
- Equipment types
- Sharps
- Plastic
- Emissions

Research Focus Questions

- How much T1D-related waste do I produce?
- How much does the world produce?
- Where do I fall in comparison?
- How, if possible, can I reduce my waste?
- What would global T1D waste production look like using myself as an example?

Particular focus on hazardous waste

Methods

- Collection over 90 days, 35 L
- Mass + Volume
- Product Identification
- Item Categorization
- Extrapolation
- Comparison

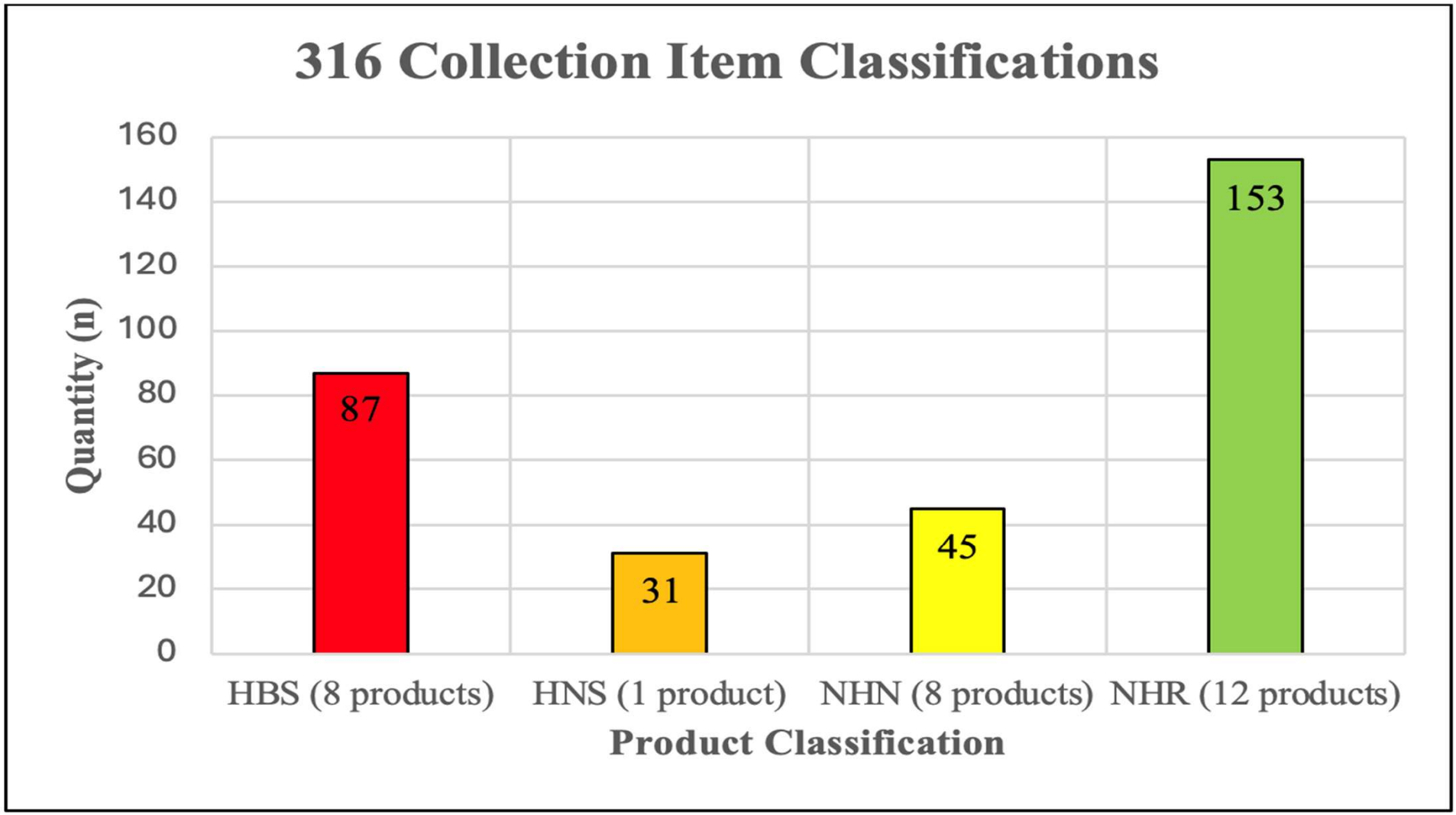
Categorization

Medical Waste

- **a. Hazardous**
  1. **HBS** - Hazardous Blood-Soaked
  2. **HNS** - Hazardous Non-Blood-Soaked
- **b. Non-Hazardous**
  3. **NHN** - Non-Hazardous Non-Recyclable
  4. **NHR** - Non-Hazardous Recyclable


PODS

316 Discarded T1D Items Over 90 Days			
1.	Dexcom G7 applicator	7	HBS
2.	Dexcom G7 sensor	7	HBS
3.	Dexcom G7 overpatch adhesive	7	NHN
4.	Dexcom G7 overpatch	7	NHN
5.	Dexcom G7 instructions	7	NHR
6.	Dexcom G7 box	7	NHR
7.	Dexcom G6 applicator	6	HBS
8.	Dexcom G6 sensor	6	HBS
9.	Dexcom G6 transmitter	1	HBS
10.	Dexcom G6 individual packaging	6	NHN
11.	Dexcom G6 instructions	2	NHR
12.	Dexcom G7 box	2	NHR
13.	Omnipod 5 insulin pump	31	HBS
14.	Omnipod 5 insulin insertion syringe	31	HNS
15.	Omnipod 5 individual packaging	31	NHN
16.	Omnipod 5 insulin pump box	7	NHR
17.	Finger lancet	3	HBS
18.	Adhesive remover wipe	26	HBS
19.	Alcohol wipe	81	NHN
20.	1000-unit insulin vial	3	NHN
21.	1000-unit insulin vial box	3	NHR
22.	1000-unit insulin vial instructions	3	NHR
23.	300-unit pen refills	15	NHN
24.	300-unit pen refill packaging	3	NHN
25.	300-unit pen refill box	3	NHR
26.	Pen refill cartridge instructions	3	NHR
27.	Unused Novorapid insulin pen	3	NHR
28.	Unused Toujeo insulin pen	3	NHR
29.	Contour glucose test strip bottle	2	NHR


316 Collection Item Classifications
Quantity (n)
160
140
120
100
80
60
40
20
0
87
31
45
153
HBS (8 products)
HNS (1 product)
NHN (8 products)
NHR (12 products)
Product Classification

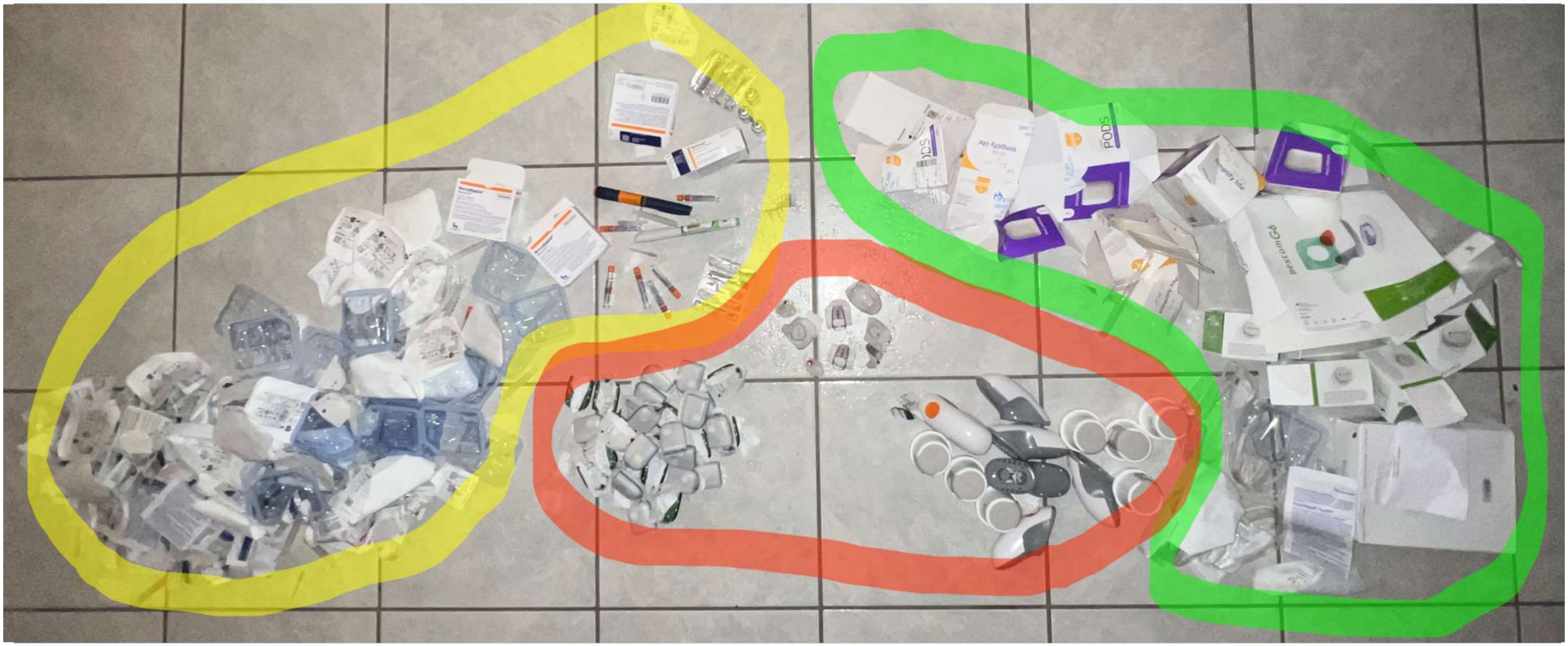

PODS

Table 2: T1D Hazardous vs. Non-Hazardous Statistics

Study Estimation	Sample Waste Generation			Worldwide Waste Generation	
Classification	Months (m)	Items (n)	Mass (kg)	Items (B n)	Mass (M kg)
Hazardous ▷	1	39	0.6	0.5	6.0
	3	118	1.8	1.5	18.0
	12	472	7.2	5.9	71.8
Non-Hazardous ▷	1	66	0.5	0.5	6.0
	3	198	1.4	1.5	18.0
	12	792	6.0	5.9	71.8
Total ▷	1	105	1.1	1.0	12.0
	3	316	3.2	3.0	35.9
	12	1264	13.2	11.8	143.5

Extrapolated statistics for 9.2 million type 1 diabetics are based on 3 factors:

A. Global data estimates 50% of T1D waste is hazardous

B. Global data estimates T1D waste to be 1.2-1.4 kg per person per month (averaged to 1.3 kg for consistency and simplicity)

C. Estimation of 11.8 billion annual discarded items based on collection and published data (316 items/90 days)

Table 3: T1D Waste Extrapolation Differences

Classification	Collection Mass (kg)	Collection Extrapolation (M kg)	Extrapolated Global Mass (M kg)	Extrapolation Difference (M kg)
Hazardous	7.2	66.2	71.8	**5.6**
Non-Hazardous	6.0	55.2	71.8	**16.6**
Total	13.2	121.4	143.5	**22.1**

The Big Picture

Without the failed sensors, I would have produced 292 items (24 items less) than global average per 90 days

So, if *everyone lived like me*, (excluding biomedical device malfunctions)…

Items: 1168/year x 9.2 million = 11.1 billion (700 million item difference)

Mass: 1.1 kg/month (as opposed to 1.3) = 121.4 million kg/year

Waste savings of **22.1 million kg/year** saved – 5.6 million hazardous kg/year

So WHY is this important?

Average **⅙ hospitals beds** occupied by diabetics

5% of global GHG emissions result from the healthcare industry

Emissions from **44%** of this 5% are linked to the treatment of diabetes complications

Diabetes, both Type 1 and Type 2, are greatly underrepresented and underresearched when it comes to climate change

Hazard Mitigation

- 3 products of concern: Dexcom G6 sensor, Dexcom G7 sensor, Omnipod 5
- Cutting off cannula or sensor filament
- Batteries – proper incineration and lithium recovery
- Optimized, safe, and effective product use (particularly CGMs)
- Some product categories may change with any blood contact

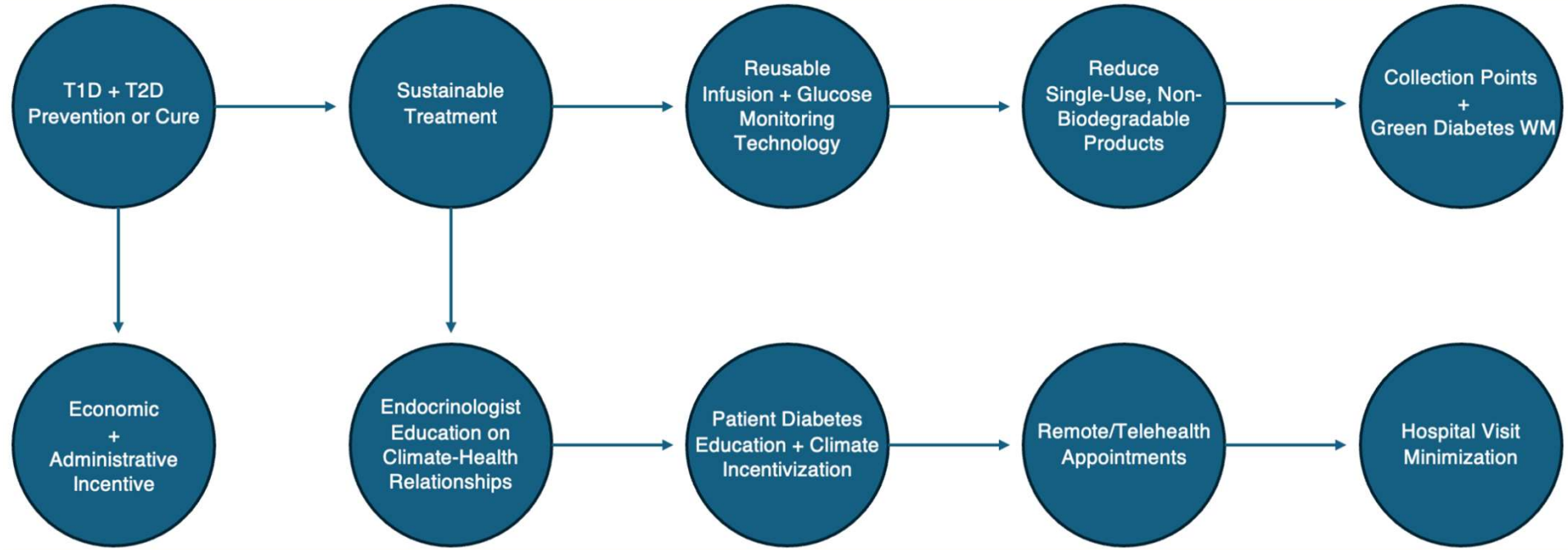
Recommendations

- More T1D-specific studies needed
- Standardized classification, collection, and disposal procedures
- Reduce likelihood for manufacturing errors
- Biobased polymers - PLA, PHA, PA 11
- Longevity and reliability
    - Transmitter and insulin pen reuse
    - Refillable pump cartridges
    - Product placement
    - Overpatch discontinuation

Summary

- Type 1 Diabetes is severely misunderstood
- Overlooked regarding its effects on the environment
- Hazardous waste classifications influence product disposal
- Intersection between climate and human health
- Big changes can start on small scales
    - -0.2 kg/person/month = 22.1 M kg waste savings

Future Outlook



Thank you!

Acbrd. (2025). What Do People with Diabetes Think and Do about Diabetes Waste? *ACBRD*, acbrd.org.au/2025/05/22/what-do-people-with-diabetes-think-and-do-about-diabetes-waste/

Akenji, L., Bengtsson, M., Kato, M., Hengesbaugh, M., Hotta, Y., Aoki-Suzuki, C., Gamaralalage, P. J. D., & Liu, C. (2019). Circular Economy and Plastics. In *Circular Economy and Plastics: A Gap-Analysis in ASEAN Member States* (pp. 14–20). *Institute for Global Environmental Strategies*, http://www.jstor.org/stable/resrep21872.6

Avari P, Cai Y, Verma V, Reddy M, Srinivasan M, Oliver N. (2024). Batteries Within Diabetes Devices: A Narrative Review on Recycling, Environmental, and Sustainability Perspective. *Journal of Diabetes Science and Technology*, doi:10.1177/19322968241278374

Banga, B. (2024). The Rise of Bioplastics in Medical Devices. *Medical Technology: Issue 76*. *Medical Technology* medical-technology.nridigital.com/medical_technology_jul24/the_rise_of_bioplastics_in_medical_devices

B.M.C. Medicine (2023). Diabetes and climate change: breaking the vicious cycle. *BMC medicine*, *21*(1), 281. https://doi.org/10.1186/s12916-023-02980-x

Carré, A., Vecchio, F., Flodström-Tullberg, M., You, S., & Mallone, R. (2023). Coxsackievirus and Type 1 Diabetes: Diabetogenic Mechanisms and Implications for Prevention. *Endocrine reviews*, *44*(4), 737–751. https://doi.org/10.1210/endrev/bnad007

De Kort, H., de Koning, E. J., Rabelink, T. J., Bruijn, J. A., & Bajema, I. M. (2011). Islet transplantation in type 1 diabetes. *BMJ: British Medical Journal*, *342*(7794), 426–432. http://www.jstor.org/stable/20839547

Dexcom. (2026). Technical Support. *Dexcom*

Faculté de Médecine. (2025). *Type 1 Diabetes*. Faculty Diabetes Center. *University of Geneva*, 29 Aug. 2025, www.unige.ch/medecine/diabetescentre/en/home/type-i-diabetes.

Fisher, B. E. (1996). Dissolving Medical Waste. *Environmental Health Perspectives*, *104*(7), 708–710. https://doi.org/10.2307/3433215

Janik-Karpinska, E., Brancaleoni, R., Niemcewicz, M., Wojtas, W., Foco, M., Podogrocki, M., & Bijak, M. (2023). Healthcare Waste-A Serious Problem for Global Health. *Healthcare (Basel, Switzerland)*, *11*(2), 242. https://doi.org/10.3390/healthcare11020242

Kantai, T. (2020). *Confronting the Plastic Pollution Pandemic*. International Institute for Sustainable Development (IISD). http://www.jstor.org/stable/resrep29273

Mallick PK, Salling KB, Pigosso DCA, McAloone TC. (2022). Designing Take-Back for Single Use Medical Devices: The Case of ReturpenTM. *Journal of Diabetes Science and Technology*, 16(6):1363-1369, doi:10.1177/19322968221088329

Masierek, M., Nabrdalik, K., Janota, O., Kwiendacz, H., Macherski, M., & Gumprecht, J. (2022). The Review of Insulin Pens-Past, Present, and Look to the Future. *Frontiers in endocrinology*, *13*, 827484. https://doi.org/10.3389/fendo.2022.827484

Montoya, J. M., Thompson, B. M., Boyle, M. E., Leighton, M. E., & Cook, C. B. (2021). Patterns of Sharps Handling and Disposal Among Insulin-Using Patients With Diabetes Mellitus. *Journal of diabetes science and technology*, *15*(1), 60–66. https://doi.org/10.1177/1932296819882926

Pegg, M., Bray, B. D., Chan, M. S., de Laguiche, E., Tyagi, A., & Di Brino, E. (2025). Environmental sustainability in diabetes: improving the quality of diabetes management through HTA and system-level change?. *International journal of technology assessment in health care*, *41*(1), e84. https://doi.org/10.1017/S0266462325103206

Perugini F, Mastellone ML, Arena U. (2005). A life cycle assessment of mechanical and feedstock recycling options for management of plastic packaging wastes. *Environ Prog*. 24(2):137-154.

Petry, S. F., Bienhaus, M., Petry, F. W., Petry, J. K., Heinemann, L., & Gäth, S. (2024). Quantification of Different Types of Waste and Batteries Associated With the Widespread Usage of Continuous Glucose Monitoring Systems. *Journal of diabetes science and technology*, 19322968241305161. Advance online publication. https://doi.org/10.1177/19322968241305161

Petry SF, Petry FW, Petry JK, Gäth S, Heinemann L. (2024). Diabetes Technology and Waste: A Real-World Study in a Specialized Practice in Germany. *Journal of Diabetes Science and Technology*, 19(6):1561-1569, doi:10.1177/19322968241257004

Predieri, B., Bruzzi, P., Bigi, E., Ciancia, S., Madeo, S. F., Lucaccioni, L., & Iughetti, L. (2020). Endocrine Disrupting Chemicals and Type 1 Diabetes. *International journal of molecular sciences*, *21*(8), 2937. https://doi.org/10.3390/ijms21082937

Satpal Singh. (2001). Mismanaging Hospital Waste. *Economic and Political Weekly*, *36*(16), 1297–1298. http://www.jstor.org/stable/4410507

Steinmetz-Wood, S., Kennedy, A. G., Hitt, J. R., Barrett, K., & Gilbert, M. P. (2025). Perceptions of Endocrine Clinicians Regarding Climate Change and Health. International Journal of Environmental Research and Public Health, 22(2), 139. https://doi.org/10.3390/ijerph22020139

Thompson PJ, Shah A, Ntranos V, Van Gool F, Atkinson M, Bhushan A. (2019). Targeted Elimination of Senescent Beta Cells Prevents Type 1 Diabetes. *Cell Metab*, 29(5):1045-1060.e10, doi: 10.1016/j.cmet.2019.01.021

Type1support. (2026). How to Reduce and Recycle Type 1 Diabetes-Related Waste. *Support*, 18, type1support.ca/en/how-to-reduce-and-recycle-type-1-diabetes-related-waste/

Winkelkötter J, Reitz T. (2021). Analysis of the Waste Volume and CO2-Equivalent Caused by the Use of Selected Patch Pumps. *Journal of Diabetes Science and Technology*, 16(4):896-903, doi:10.1177/1932296821991523