Using the Persuasive Design Model to Refine a Novel Stimuli-Responsive Polymeric Sensor in Head and Neck Cancer Patients

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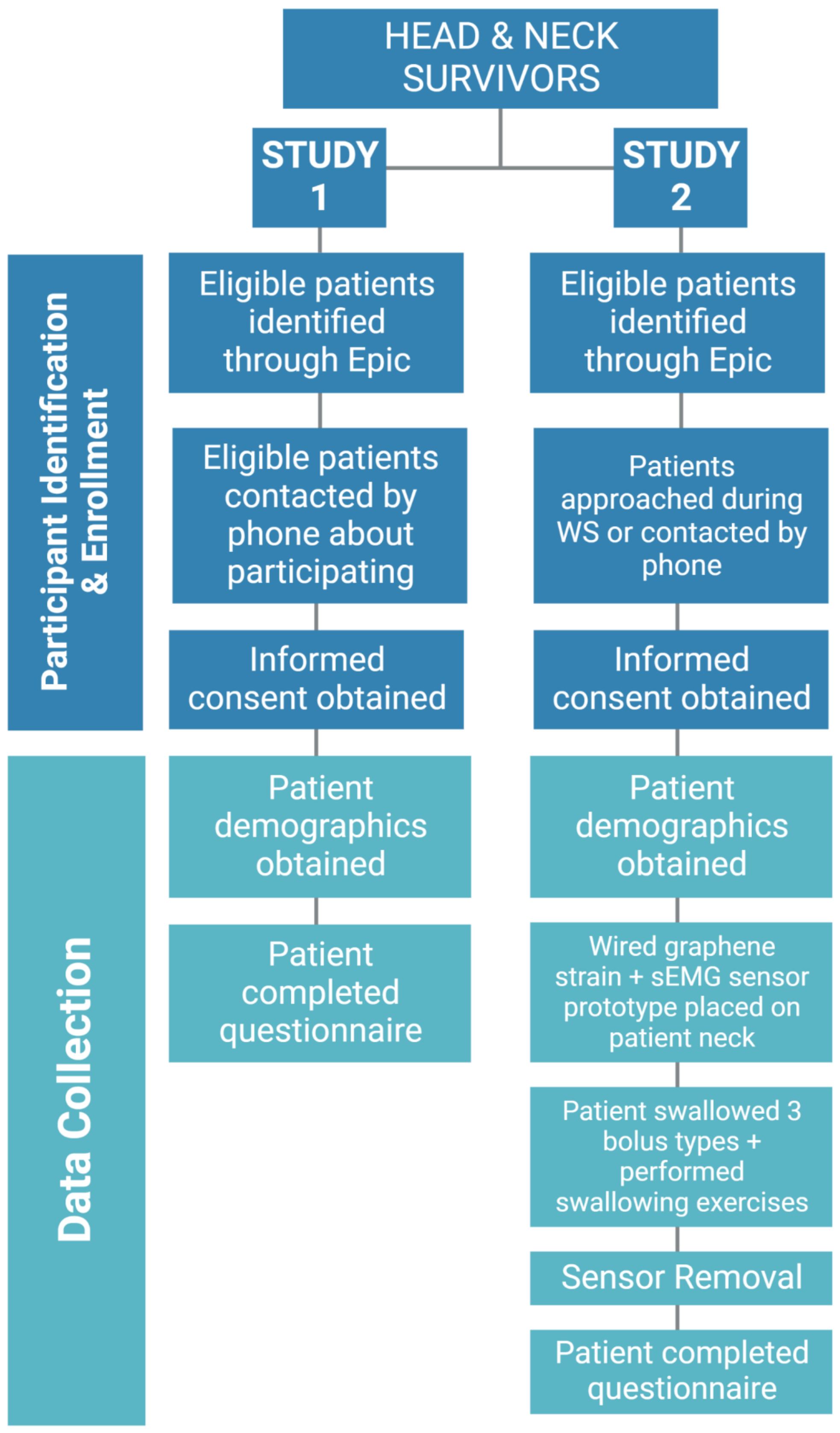
BACKGROUND

We conducted two user-centered tests with head and neck survivors to evaluate long-term usability of a novel sensor (Fig 1) to detect developing dysphagia after radiation. Radiation-associated dysphagia is permanent and occurs in 40% of laryngeal/pharyngeal cancer patients treated with curative radiation. We prototyped a neck-worn epidermal dual-layer strain/sEMG sensor that measures swallowing muscle activity to aid in the earlier detection of dysphagia development. Ideally, home-based monitoring with the sensor during the post-radiation treatment period would detect developing dysphagia in time to initiate preventive interventions. However, most U.S. patients abandon wearable health technologies within months, lessening their clinical impact. To sustain patient engagement, user-centered testing is needed but often neglected in the development of these technologies. To evaluate the sensor's long-term usability, we used the Persuasive Design Model[1] to test 4 parameters of technology: ***ease of use, sensor feedback, credibility and social support*** (Fig. 2).

AIM

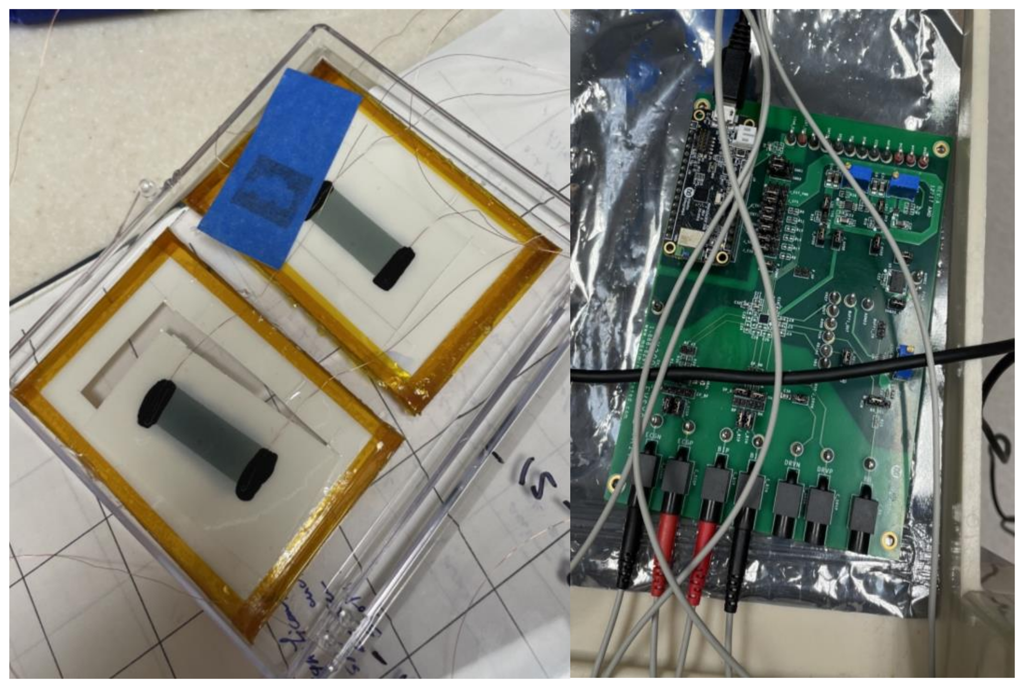
To determine patient design preferences and barriers to long term use of a neck-worn epidermal dual-layer strain/sEMG sensor within the persuasive design model.

METHOD



RESULTS

Fig. 1 **Strain sensor on tattoo paper (left) electrical board (right):**



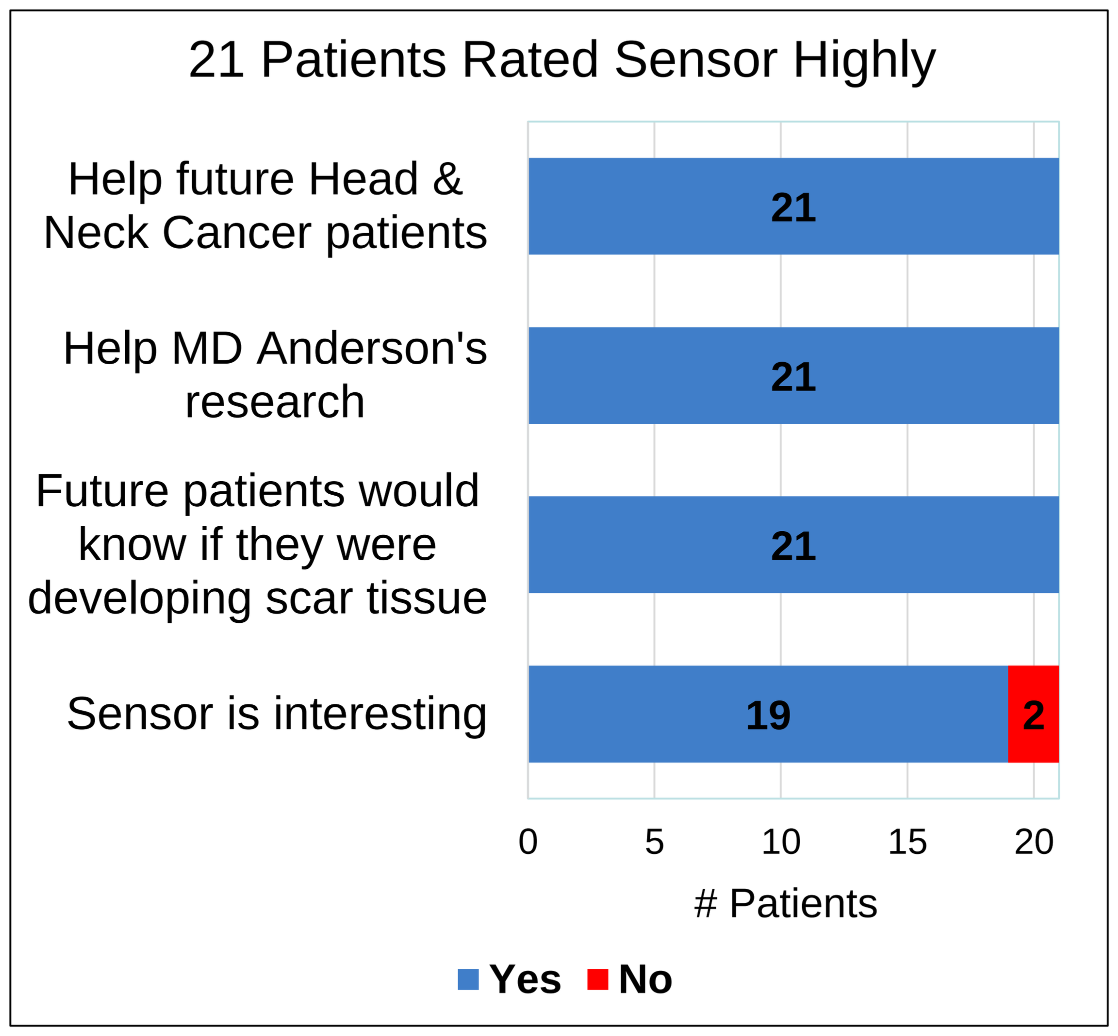
Participant Demographics

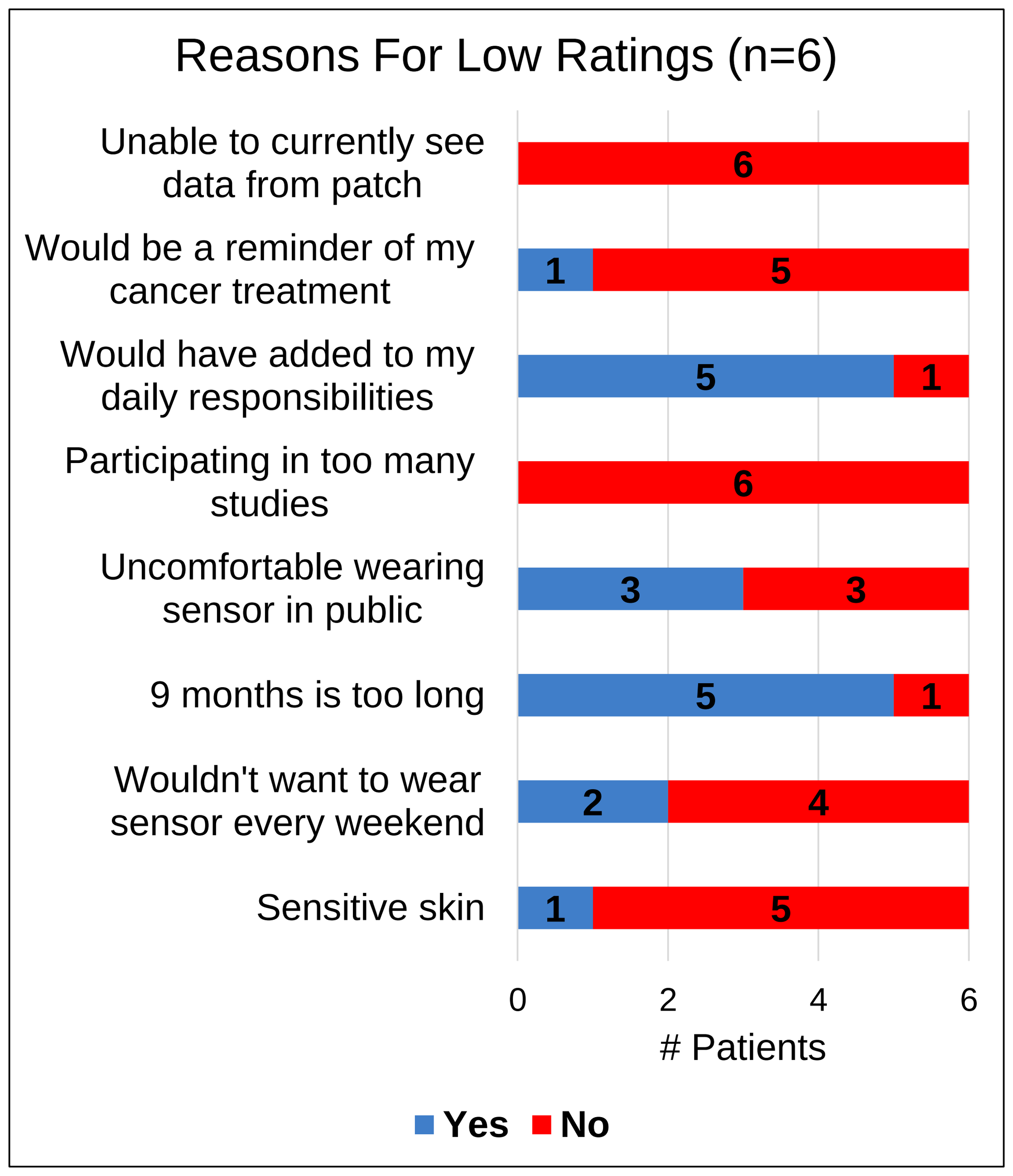
Participant Demographics	
Variables	**n=138**
Age (yrs.), range, median	(18-83); 59
Race/Ethnicity, Asian	3.6%
American Indian or Alaska Native	0%
Non-Hispanic White	92.7%
African American	2.9%
Native Hawaiian or Pacific Islander	0.7%
Education, </= High school graduate	18.4%
Some college credit or Bachelor's degree	57.4%
Master's degree/M.D/PhD etc.	24.3%
Employment status, full/part-time	73.6%
Married/S.O.	81.5%

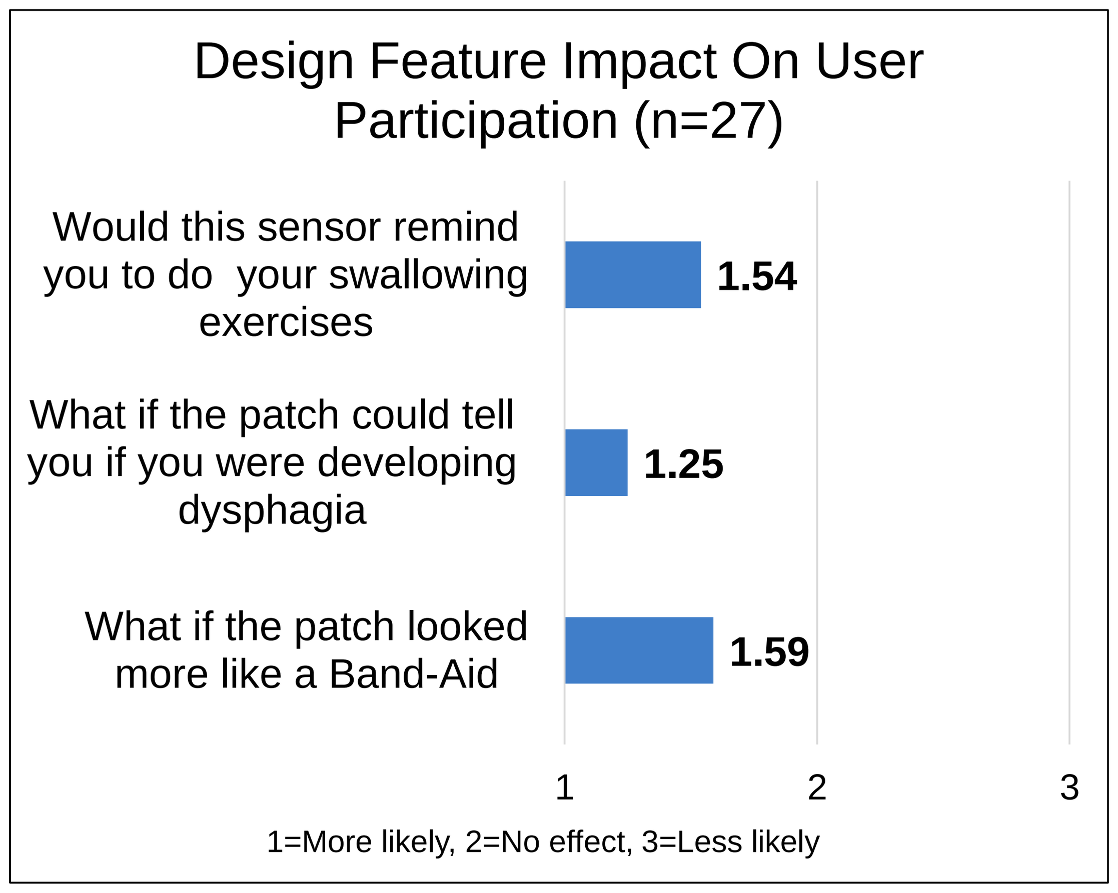
Study 1 Attitudes Toward Sensor n=138

Study 1	Would participate N= 115 (83.5%)		Would not participate N=23 (16.5%)	
Question	True	False	True	False
Sensor is interesting	92 *87.6%*	13 *12.4%*		
Would remind me to do swallowing exc.	75 *77.3%*	22 *22.7%*		
I wanted to help MD Andersons research.	108 *99.1%*	1 *0.9%*		
Sensitive Skin			11 *50%*	11 *50%*
Wouldn't want to wear sensor every weekend			14 *63.6%*	8 *36.4%*
9 months is too long			19 *86.4%*	3 *13.6%*
Uncomfortable wearing sensor in public			12 *57.1%*	9 *42.9%*
Participating in too many studies.			1 *5.3%*	18 *94.7%*
It would have added to my daily responsibilities.			11 *55.0%*	9 *45.0%*
Would be a reminder of my cancer treatment.			6 *30.0%*	14 *70%*
Unable to currently see sensor data			6 *28.6%*	14 *71.4%*

Study 2 Real-World Sensor Testing with 27 Head and Neck Cancer Patients







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DISCUSSION

Patients agreed that the 9-month period was the biggest hurdle to at-home use. Three Persuasive Design needs were identified: ***Ease of Use.*** Sensor application was cumbersome; ***Sensor Feedback.*** Haptics (vibration signals) would improve sensor placement and exercise movement accuracy; ***Credibility.*** In order to support long-term use, patients desired bidirectional communication with their treatment team via the sensor system, e.g. the treatment team could monitor developing dysphagia and send back interpretations of data to educate the patient. (Kim 2017) **Limitations.** Those who agreed to participate in Study 1 were more likely to be non-Hispanic (p=0.003), had a college degree (p= 0.022), and had higher annual household incomes (p=0.038) compared to non-responders.

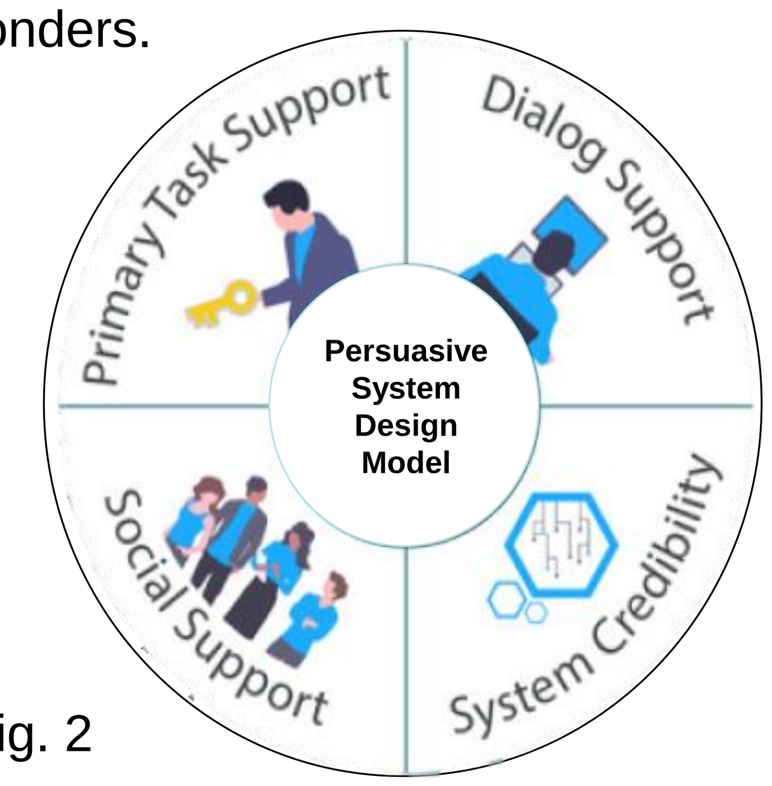

Fig. 2

FUTURE DIRECTIONS

Moving forward, the sensor's design and application should become more streamlined. To do this, user-centered testing should be utilized at every stage of development to sustain engagement throughout the 9-month post-radiation period.

CONCLUSION

Our patient data supported three main parameters of the Persuasive Design Model: ease of use, user feedback and credibility. Survivors were willing to use advanced technologies to support adherence to preventive strategies, but this willingness was dependent on how seamlessly the sensor would integrate with their lifestyle and post-treatment radiation side effects.

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