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US fl oz
TO PREVENT LEAKS
DO NOT FILL ABOVE LINE
fl oz

Bottle Drive

One in four infants and toddlers will struggle with feeding, a condition that leaves many parents feeling frustrated, anxious, and guilty. Connell School of Nursing Assistant Professor Britt Pados is on a mission to help pediatricians, hospitals, and specialists improve the way they identify and care for these vulnerable children.

BY DEBORAH HALBER

PHOTOGRAPHS BY LEE PELLEGRINI

IN MALONEY HALL earlier this year, a breast pump sat on a table, chugging like a metronome as it propelled formula through a baby bottle and into a glass beaker. After a minute, Britt Pados '03, an assistant professor at the Connell School of Nursing, recorded the amount of formula in the beaker, poured it back into the bottle, screwed a new silicone nipple into place, and restarted the machine.

For hours, as the timer beeped at sixty-second intervals, Pados recorded the rate at which formula flowed through various brands of bottle nipples. In jeans and a blazer, with an Apple watch on her wrist, Pados screwed and unscrewed plastic ring after plastic ring. It's far from glamorous, but Pados's work is helping to improve the artificial nipples used by millions of babies every day in hospitals and homes across the world.

It turns out that there are no objective standards for bottle nipples. Their flow rates vary wildly, and their marketing claims can be confusing to the point of being meaningless. That matters because specialists and researchers like Pados believe that nipple-flow rates—literally, the rate at which nourishing fluid enters a baby's mouth—can contribute to infant feeding problems. That's especially concerning at a time when increasing numbers of parents are reporting such problems. The National Institutes of Health estimates that as many as one in four infants and toddlers are affected by feeding struggles.

Problems with feeding can pose health risks for babies and be a major source of anxiety for parents. Of the many things that expectant parents lose sleep over, their newborn's ability to feed is rarely on the list. Drinking formula or breast milk seems like something that will just happen organically. When it doesn't, it can feel like failing Parenting 101. "Feeding is a big part of establishing a bond with a baby," Pados said. "When that's not going well, that's really stressful, because they need to eat to live." One study likened parental reactions to their preemies' feeding issues to post-traumatic stress disorder.

Pados's work is changing the way that hospitals, parents, and specialists across the country select bottle nipples. But nipple-flow rates are just one of the factors that can contribute to infant feeding problems. Pados has also created assessment tools that are helping parents and pediatricians better identify and treat babies suffering from problems that range from long-term refusal of certain foods to inadequate nutrition during critical periods of brain development. And sometimes, at night, Pados will find herself responding to emails from desperate parents looking for help with feeding problems. She knows firsthand just what they are going through.

GROWING UP in Texas and Connecticut, Pados loved to hear her grandmother, a pediatric nurse, tell stories about the children she cared for. "I knew pretty early on that I wanted to pursue a career related to the health care of children," Pados said. That led her to BC's undergraduate nursing program, during which she spent time in a neonatal intensive care unit, or NICU. She fell in love with the intensity and focus of the NICU environment and, after eventually earning a master's degree in nursing from the University of Pennsylvania, Pados became a neonatal nurse at Beth Israel Deaconess Medical Center in Boston and then a nurse practitioner at Morgan Stanley Children's Hospital of New York-Presbyterian.

She worked with infants being treated for heart problems. It amazed her whenever parents would tell her that the most difficult part of the ordeal was not the cardiac surgery itself, but the weeks their infant would spend in the NICU afterward while learning to feed properly. "I think parents can say, *It's not my job to do heart surgery. It's not my job to manage medications*," she said. "But being unable to feed your baby can feel like a personal failure."

In 2007, Pados began working on her Ph.D. in nursing at the University of North Carolina Chapel Hill. Three years into the program, she gave birth to twins, a boy and girl—and learned all about the stresses of infant feeding problems. Pados first experienced contractions at twenty-three weeks, when the babies could have barely survived on their own. They ended up being born only a few weeks premature, but still needed to be fed through feeding tubes in the NICU. Pados knew the tubes snaking into their noses and throats would be in place until the babies could eat on their own. It wasn't until day ten that her son went home. When she returned to the hospital the next day, she was devastated to find her daughter, who had been taking breast milk and formula through a bottle, back on a feeding tube. It was another week before her daughter had mastered feeding well enough to go home. "Those were the longest eighteen days of my life," Pados said. After completing her Ph.D. in 2012, she worked at UNC as a clinical assistant professor and adjunct professor focused

on the feeding issues faced by very preterm infants. She has continued and developed that work since joining BC as an assistant professor in 2017.

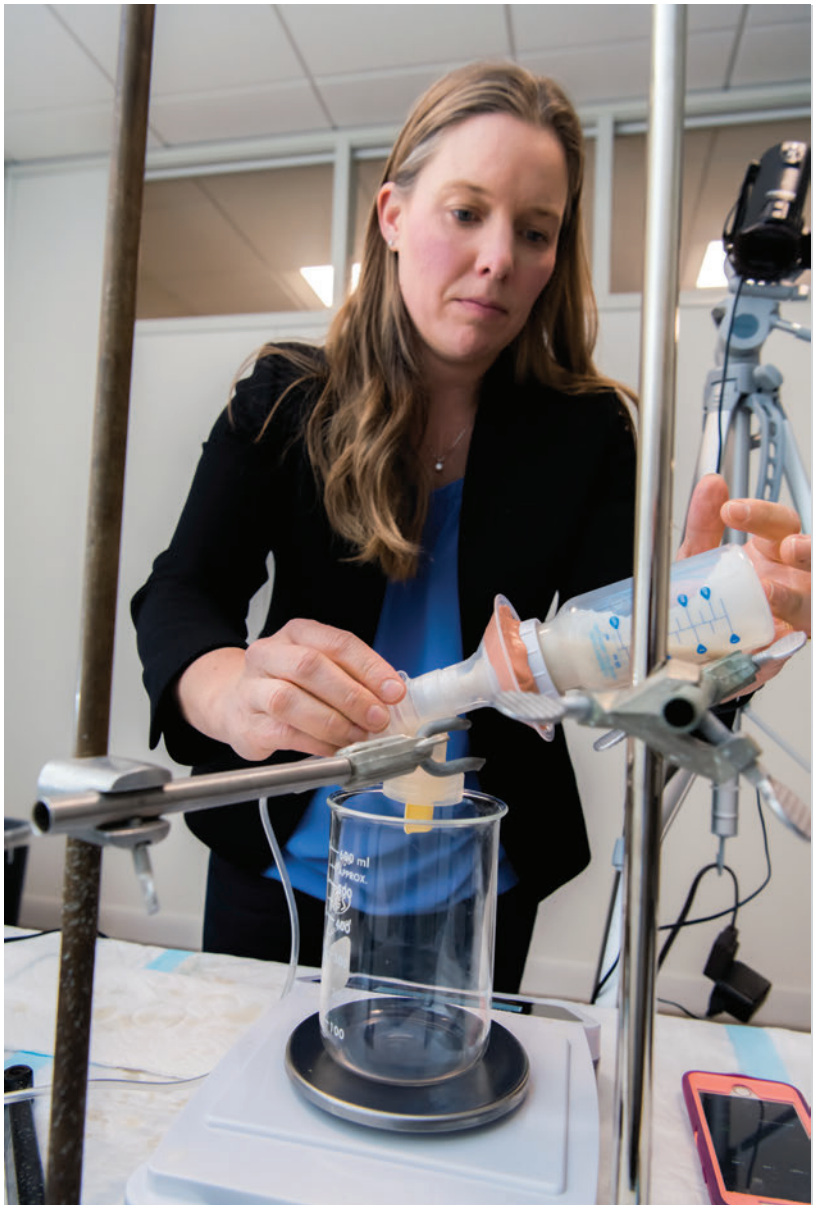
IN THE MALONEY HALL TESTING ROOM, boxes of bottle nipples were stacked on the floor and dozens of nipples in purple, blue, and orange rings awaited testing. This batch had come from Australia, the result of a research collaboration between Pados and a speech pathologist in that country. Over two days of testing in January, Pados and Rebecca Hill, a Ph.D. student in the Connell School of Nursing, measured their flow rates. Differences among the nipples were glaring enough to be apparent to the naked eye: Some emitted tiny drips into the beaker; others, significant drops.

A nipple's flow rate can be crucial, because the mechanics of swallowing formula or breast milk are anything but simple. In many ways, feeding is the CrossFit of infancy. "It's the most physically strenuous and complex thing we ask them to do," Pados said. Every swallow requires a baby to hold his or her breath for around a second. "For babies who are premature or have respiratory or cardiac issues, we're asking them to suck, swallow, suck, swallow, so that they're interrupting their breathing a lot," Pados said.

A couple of decades ago, she said, medical personnel interpreted preemies' discomfort during feeding as fatigue. If milk came out of the bottle faster, they reasoned, the feeding would go faster and be easier on the baby. "What we didn't know at the time was that the reason they were getting tired was because they were having to hold their breath so much," Pados said. "A lot of these babies can't hold their breath that much without becoming distressed. If we slow down the flow rate, it allows them to breathe more. It slows down the pace of the feeding."

When liquid exits a nipple too rapidly, she said, it can cause coughing or choking. Imagine running on a treadmill while trying to drink water being squirted into your mouth from a bottle. You'd hold your breath long enough to swallow but would end up gagging if the timing or volume of liquid wasn't what you expected. Many newborns cope with a similar situation every time they eat, said Kayla Hernandez, a speech-language pathologist at Boston Children's Hospital who works each week with up to forty children—from birth through age six—with eating disorders. It can be overwhelming and stressful and cause babies to not want to eat, and that can lead to feeding disorders. In extreme cases, she said, some children refuse all food and liquids, and need feeding tubes to survive.

The nipples Pados and Hill were testing in January were brands available in Australian stores, but there are plenty of problems with fluctuating nipple-flow rates in



Britt Pados tests the rate at which baby formula flows through a bottle nipple. Pados's work is helping hospitals and parents determine which nipples are suitable for infants learning to feed.

this country, too. American hospitals, for instance, typically rely on bottle nipples that are supplied free of charge by formula manufacturers. Those nipples can be labeled everything from "slow flow" and "extra slow" to "standard flow" and "premature." But Pados has found that these designations often have no relation to the volume of liquid the nipples dispense.

Then there are the hundreds of brands of nipples found on store shelves. Prior to joining the Ph.D. program, Hill had worked as a nurse caring for adult diabetics, and she planned to research diabetes self-management while at BC. Then her second child was born with a condition that affects 3 million infants every year: ankyloglossia, or tongue-tie, which restricts the tongue's range of motion and can lead to eating difficulties.

Three days after giving birth to her daughter, Hill stood in front of a daunting display of molded synthetic nipples at Babies R Us: NUK, Nuby, BabyBrezza, Pur, Latch, Dr. Brown's, Gerber, Philips Avent, LifeFactory. Some were latex, some silicone. Hill simply could not figure out what would be best for her daughter, and wound up buying a dozen brands of bottles and nipples. In the special-care nursery, she watched her daughter struggling to coordinate eating and breathing, sometimes turning blue from lack of oxygen. When her daughter's feeding issues were eventually resolved, Hill decided to change her focus from diabetes to feeding difficulties for children with tongue-tie. She sought out Pados and began to work with her on quantifying nipple-flow rates.

Hill's experience at Babies R Us has been confirmed by the extensive testing that Pados has done. In 2013, for instance, she and a team of researchers at UNC found nipple flow rates that varied from 6 to 60 milliliters per minute. Labels such as "slow," "standard," and "premature" had little or no correlation to flow rate. The Similac Premature was faster than the Similac Standard Flow. Enfamil's slow-flow nipple, meanwhile, was almost twice as fast as Similac's.

A 2016 study found even steeper variations: Milk-flow rates varied from 1.68 milliliters per minute for Avent Natural Newborn Flow to 85.34 milliliters per minute for Dr. Brown's Standard Y-cut—potentially an ocean of difference to a tiny throat. "What we learned from those studies," Pados said, "was that the name that's assigned to the nipple does not necessarily mean anything about the flow rate."

For Shannon Goldwater, feeding issues of multiple forms surfaced after her triplets were born prematurely in 2002. Each of Goldwater's babies weighed only a little more than a pound at birth, and spent four months in a NICU in Scottsdale, Arizona. At age 17, one of her sons still needs a feeding tube to meet basic nutritional needs. And because of a long-undiagnosed throat condition, her daughter refused liquids for more than a year and required frequent intravenous hydration.

Ideally, treatment for children such as Goldwater's triplets would come from a team of medical specialists, including psychologists, speech-language pathologists, and nutritionists. Yet, a 2010 study in the journal *Nutrition in Clinical Practice* found that very few medical centers offer such inter-

disciplinary clinics, which can result in difficulties coordinating care and "suboptimal treatment outcomes." What's more, a 2015 study of family medicine, internal medicine, and pediatrics residency programs, published in the *International Journal of Eating Disorders*, reported that fewer than 10 percent included specific training on eating disorders.

With these problems in mind, Pados, Jinhee Park—an assistant professor in the Connell School of Nursing—and a team of researchers from UNC developed five assessment tools to help parents and caregivers pinpoint feeding issues early.

"Our team's assessments are more rigorous, researched-based, and comprehensive than those that typically take the form of questionnaires," said Park, who was on the same research team as Pados at UNC. She added that parents have told her, "I know my child has a feeding issue" but then have trouble articulating the specifics to a health care provider. Working through the questions within the assessment tools, she said, can help parents understand the nature of their child's issues and better communicate them.

One of the assessments, called NeoEAT, evaluates symptoms of problematic feeding in infants younger than seven months old who are bottle- or breastfeeding. Providers or parents answer sixty-eight questions and then receive a score indicating whether a baby's eating experiences are a cause for concern. PediEAT, meanwhile, is for children six months to seven years who are being offered some solid foods. Other tools assess oral and motor proficiency skills in children between the ages of six months and seven years who are being offered solid foods; measure the impact of feeding on the parent and family; and look at how families manage their child's feeding difficulty.

Pados's goal for the assessments is to identify earlier the children who are struggling with feeding, which would aid them in getting the help they need sooner. "My hope," she said, "is that feeding specialists can use the information from these assessments to personalize their treatment strategies to best meet the needs of the child and their family."

> Pados has personal experience with the anxiety that the parents who write her are feeling: "Feeding is a big part of establishing a bond with a baby. When that's not going well, that's really stressful, because they need to eat to live."

THE ASSESSMENT TOOLS (available at feedingflock.com) have begun to make a difference. So far, more than 4,000 people—mostly medical professionals, but also parents—have requested access to them, Pados said, and they're being used in inpatient and outpatient feeding clinics, neurodevelopmental follow-up clinics, and pediatric primary care.

Pados's work on nipple-flow rates, meanwhile, has caused hospitals and baby feeding equipment manufacturers to take notice. Kayla Hernandez at Children's Hospital said that "with Britt's work, we've been able to identify which of the slow-flow nipples are actually the slowest and therefore potentially the best fit for our young infants." Other hospitals have also made changes. In response to Pados's research showing that the widely used "Similac Premature"—known as the "red nipple" for its distinctive color—was very fast, many hospitals no longer stock that nipple for use in the NICU. Others have switched to Dr. Brown's products instead of the disposable nipples provided by Enfamil and Similac. Enfamil recently created the new Enfamil Extra Slow Flow after hospitals requested a slower-flow nipple than the products the company had historically offered.

Pados has also corresponded with the biomechanics expert Tommy Cunningham, COO and cofounder of Atlanta-based NFANT Labs, a medical device and digital health company working to improve the standard of care in infant feeding by providing objective, evidence-based medical products and services. When Cunningham's company asked nurses and clinicians on the front lines of infant feeding in the NICU what they wanted in a feeding system, "one of the biggest frustrations we heard from them was the lack of reliability and consistency in flow rates from Enfamil and Similac nipples," he said. NICU staff members reported problems ranging from "sometimes there is no hole" to "the flow can be so fast I was drowning my patient."

Ultimately, Pados would like to see all baby feeding equipment manufacturers following NFANT's lead in conducting rigorous, science-based clinical testing of nipple-flow rates and other feeding systems—and disseminating the resulting data. "What I try to do is give people information to make decisions," she said. "It's all about finding a balance between what's safe for the baby and what's efficient for the baby."

For her part, Goldwater is grateful that all of these issues are finally getting long-needed attention. The challenges her preemie triplets faced with feeding were profound enough that she went on to cofound Feeding Matters, an organization that works to raise awareness of such problems. The stakes, she said, are high for many parents and infants, "which is why we're so thankful for practitioners like Britt who are really making a difference, so kids like mine don't spend years and years suffering." ■

Deborah Halber is a freelance journalist who often writes about science. Her work has appeared in *The Boston Globe*, *MIT Technology Review*, and *Boston* magazine.