

Marshall Henry Klaus (1927-2017)

Marshall Henry Klaus was a scientist and pediatrician who studied maternal-infant bonding in the twentieth century in the United States. Maternal-infant bonding is the psychological and chemical attachment between mother and infant. Klaus cofounded DONA International, an organization that trains birthing aides, called doulas, to provide physical and emotional support to laboring mothers. He also studied the differences between the layouts and quality of care provided in nurseries and birthing centers in different countries and compared them to those found in the United States. Klaus's study influenced national and international initiatives to create hospital policies focused on promoting early bonding between mother and infant. Klaus catalyzed the advent of doulas and international policies that emphasized interaction between new mothers and their infants.

Klaus was born on 6 July 1927 to Caroline Epstein Klaus and Max Henry Klaus in Lakewood, Ohio. His mother was a teacher and his father was a physician. Klaus had one younger brother, Carl, who was born in 1932. The family lived near Cleveland, Ohio, where Klaus attended elementary school until his father's death in 1934. Shortly following his father's death, Klaus's mother was diagnosed with breast cancer. Klaus claimed in an interview that certain events in his childhood were important for his future career. One such event took place shortly after his mother's cancer diagnosis, when she was being treated with radiation at the Cleveland Clinic in Cleveland, Ohio. After seeing radiation burns on his mother's skin, Klaus reportedly believed the doctors were intentionally burning his mother. As a result, he noted that he kept a professional distance from that hospital throughout his entire career. Klaus also indicated that his mother's cancer eventually spread to her eyes and caused her to become blind. Klaus stated that the fact that his mother was unable to look directly at him sparked an early interest in how infants observe their mother's faces and vice versa.

After his mother died in 1933, Klaus and his brother went to live with extended family on his father's side, where they were encouraged to pursue their education. His uncle, a physician, encouraged both Klaus and his brother to prepare for a university education while putting them through high school in the inner city of Cleveland. Klaus's uncle regularly had patients and other doctors come to their home for dinner, exposing Klaus to the field of medicine. In 1945, when Klaus was eighteen, his uncle died and left the family estate to Klaus and his brother. There they could reside until after they finished their college education. That same year, Klaus was accepted into Case Western Reserve University in Cleveland, Ohio, where he completed his undergraduate studies in three years. Upon graduating in 1947, Klaus was not accepted into medical school right away. He applied the following year again and got accepted into Case Western Reserve University Medical School in Cleveland, Ohio, in 1948. During his third year of medical school, Klaus contracted polio, which caused permanent mobility problems in one of his arms, his back, and mildly, in his legs. In 1950, during a brief hiatus from school due to polio, Klaus married Lois Krieger, a chemist, with whom he had four children, however, the couple later divorced. Klaus recovered from polio and graduated from medical school with honors in 1951.

After medical school, Klaus entered a medical residency program and began researching pediatric medicine, or the medical care of infants. In 1951, he started a residency in pediatrics at the Academy of Medicine of Cleveland and Northern Ohio in Cleveland, Ohio. Initially, Klaus wanted to pursue obstetrics, the branch of medicine concerning childbirth. However, according to a later interview, Klaus chose pediatrics over obstetrics because he could not deliver infants with only one functional hand due to his polio. While in his first year of residency, Klaus attended lectures by Anna Freud, a child psychologist. Freud's lectures focused on the psychological impact of children who had lost their mother figures early in life and on the psychological effects of hospitalization on children's

development. According to Klaus, Freud's lectures resonated with his own experience of losing his mother. Those lectures also contributed to his clinical and research interests in the bond between mother and child. Klaus's focus on infant care began after the completion of his residency in 1954. Klaus practiced as a pediatrician but left primary care to do research after a few years.

Klaus began his research career by investigating the effects of different technologies on pediatric physiology. In 1959, Klaus and his family moved to Novato, California, a suburb outside San Francisco, California, where he joined the University of California, San Francisco Cardiovascular Research Institute or CVRI in San Francisco, California. Klaus originally went to study pediatric cardiology, the study of the infant's heart and vascular system, because that specialty only required three years of training. However, after one month of studying cardiology, Klaus switched to pediatric pulmonology, or the study of lungs and the respiratory system in infants. In 1960, within the first year of his training, Klaus and his family moved to Mill Valley, California, to be closer to the CVRI. There, Klaus worked on the Grass recorder, a type of early respirator that assisted newborn infants with breathing. Later, Klaus used the Grass recorder in other research labs.

Upon the completion of his training at the CVRI in 1961, Klaus and his family moved back to Cleveland, where Klaus joined a research lab affiliated with Mount Sinai Hospital. Using his experience with and knowledge of the Grass recorder, Klaus and fellow physician-scientist John Clements studied lung volumes in infants and worked to identify the mechanism of surfactant on infants' lungs. Surfactant is a viscous coating on the lungs that helps in the action of breathing. At the time, scientists knew about surfactant, but they had not yet identified where it came from or how it helped with breathing. To advance their research, Klaus went to a slaughterhouse and obtained a cow lung to study its surfactant. He washed the lung, centrifuged the tissue, and used a fat, otherwise called a lipid, extract to attempt to isolate the surfactant from the lung tissue. Klaus used a lipid extract because at the time it was commonly postulated that surfactant was a type of fat, and lipid extracts helped isolate fat. Klaus and Clements discovered that surfactant was a type of fat called phospholipid. They later went on to create artificial surfactant after determining that premature infants were often born without surfactant in their lungs. Klaus used that surfactant on his patients later.

In the early 1960s, during his time in Cleveland, Klaus received two grants from the National Institutes for Health or NIH to compare the standards of care in nurseries around the world to those found in the United States. Klaus travelled to Singapore to observe one of the country's largest hospital's maternity ward. The hospital he visited had over 150 infants born per day, yet there was no intensive care nursery. After observing a high death rate among the infants born at that hospital, Klaus and his colleagues paid to add a four-bed intensive care nursery to the hospital in Singapore. Infants who showed signs of respiratory distress were also treated with the artificial surfactant Klaus had developed during his time at Mount Sinai Hospital. In a later interview, Klaus described the conditions of the maternity ward at the hospital as one large room where, at any given time, approximately twenty-four women were in the process of delivering their infants. He indicated that the room smelled heavily of amniotic fluid, as the pregnant women were walking around and dripping amniotic fluid on the floor up until the very last moment of the birthing process. Midwives delivered the infants and the mothers never cried or screamed.

In 1963, Klaus transferred to the research department at Stanford University in Stanford, California, where he utilized his experience in Singapore and his NIH grants to continue his research in a different direction. At Stanford University, Klaus studied more neonates, or infants younger than four weeks old, at a special nursery designed for premature infants. However, while doing so, Klaus began to focus more on the mothers than the infants. Stanford's nursery was a big open room with rows of incubators and a space for mothers to sit in the corner. Klaus noted that upon examining healthy infants, the infant's mother was always watching him perform the examinations. However, when he examined premature or deformed infants, the mothers were detached and tended to be a far distance away in the sitting area for parents. According to Klaus, that initial observation, coupled with his experiences in Singapore, narrowed his research focus to the maternal side of bonding and attachment.

In 1970, Klaus published "Neonatal Separation: The Maternal Side of Interactional Deprivation," which initiated his formal research into maternal-infant bonding. In that article, Klaus detailed a

collaboration with John Kennell. Klaus and Kennell studied the early interactions between over fifty mothers and their infants within one hour of birth. At the time, the Stanford hospital prohibited parents from entering the premature infant nursery past a certain time. Kennell snuck the mothers into the nursery past official visiting hours to make their data reliable. Klaus and Kennell determined that none of the mothers who had early contact with their infant within one hour of birth gave up their infants for adoption. The number of women who gave up their infant for adoption was higher among those mothers who did not have early contact with their infants. In another similar study, Klaus and Kennell noted that mothers with premature infants were less likely to look into the eyes of their infants. They also found that mothers of healthy, full-term infants focused on having their infants look at them, saying words indicative of needing eye contact from the infant, and even going so far as to tilt their heads into the infant's plane of vision to promote eye contact. According to Klaus, that experience reminded him of his mother's blindness and lack of eye contact and furthered his desire to understand the maternal side of childbirth and infant bonding.

In 1972, Klaus received another grant from the NIH and the World Health Organization, WHO, to study the differences between nurseries in other countries and those in the United States. He found that in Sweden and Estonia infants were placed on the mother immediately following birth and the infants seemed to instinctively crawl to the mother's breast to initiate breastfeeding. Klaus also noted that early breastfeeding stimulated the prompt expulsion of the meconium, the first stool of the infant. Early release of the meconium is linked to better health outcomes for the infant throughout development.

Utilizing the NIH and WHO grant money, Klaus travelled to Guatemala in 1973 to perform clinical trials on labor and bonding. In Guatemala, Klaus and his team studied how early skin-to-skin contact between mother and infant affected their interpretation of bonding. During that study, Klaus required the pregnant women to labor alone in a room with nine other laboring women before being pulled individually into a single-occupancy birthing room with medical staff. Klaus enforced that policy because that group of women served as the control for the labor side of the study. During one of the trials, Klaus's female student unintentionally violated that rule by staying in the waiting room with ten pregnant women. However, the researchers found that while the female student was there, three women quickly gave birth without enough time or warning to be pulled into the birthing room. According to a later interview, Klaus cited that that accidental finding was the reason Klaus and Kennell began to study what was later called a doula.

Following his 1973 study in Guatemala, Klaus shifted his research focus to investigate why the presence of the female student sped up the pregnant women's laboring process. In 1980, Klaus and Kennell found that supportive companions had a positive effect on many different aspects of labor, including the length of labor, the development of perinatal problems, and the success of breastfeeding. He later named supportive labor companions doulas, derived from the Greek word meaning servant-woman. During his early studies of doulas, Klaus met Phyllis Stoller, whom he married in 1982. The two collaborated on maternal-infant bonding studies for the rest of Klaus's career and, in 1985, they published a book titled, *Your Amazing Newborn*. In 1988, Klaus became an adjunct professor of pediatrics at the University of California, San Francisco in San Francisco, California. At the same time, he also worked as the director of academic affairs at Children's Hospital of Oakland in Oakland, California.

In the 1990s, Klaus's findings influenced a global initiative and organization. In 1991, World Health Organization, or WHO, in partnership with the United Nations International Children's Fund, or UNICEF, passed the Baby-Friendly Hospital Initiative. That initiative recognized hospitals and birthing centers that focused on infant feeding and maternal-infant bonding as a Baby-Friendly Hospital, in large part due to Klaus's research. Globally, the initiative reduced the number of cases of infant abandonment. In 1992, along with his wife and Kennell, Klaus cofounded DONA International, which was then called Doulas of North America. DONA International is an organization that trains women to become certified doulas, and the organization places a large emphasis on maternal-infant bonding and breastfeeding.

Klaus continued to deliver lectures on maternal-infant bonding across the United States throughout the early 2000s. On 15 August 2017, Klaus died in San Francisco, California.

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