groups, indicating that this condition has been common for decades. This finding is supported by data from hospital records and published data that pregnancy and miscarriage under age 14 is substantially higher in Izabal[4,5] compared with Guatemala City and other major cities in the country. Puerto Barrios is located on the Caribbean coast and is geographically isolated from the rest of Guatemala. The Puerto Barrios study population was recruited from a public, urban hospital in a city of over 106,000 inhabitants, made up of admixed Amerindians/Europeans, Native Mayans (mostly speaking Q'eqchi'), and Garifuna, a population of African origin. The diversity of the population makes a genetic cause unlikely. Several plausible environmental causes may contribute to the earlier observed age at menarche in our study population, including water contamination, plant toxins related to the estrogenic compound zearalenone—a mycotoxin produced by numerous species of *Fusarium* growing on corn, or fumonisin, which is more prevelant in lowland areas of Guatemala, including Puerto Barrios.[6]

Precocious menarche is associated with adverse reproductive outcomes in young women, including an early age of pregnancy or miscarriage, and the early age at menarche we describe warrants further investigation. Understanding the factors contributing to precocious menarche in this population may be useful in helping to reduce adverse reproductive outcomes in Guatemala. ■

**ACKNOWLEDGMENTS**

The authors would like to thank the staff and health professionals from the Instituto de Cancerología, Guatemala City, Guatemala, and Hospital San Juan de Dios, Guatemala City, Guatemala; and Hong Lou, Sarita Polo Guerra, Anali Orozco, Lisa Garland, Oscar Florez-Vargas, Miriam Castillo, Patricia Zaid, Adolfo Santizo, Esther Avila, and Lineth Boror for sample and data collection and shipping. We thank Christian Alvarez, Katherine McGlynn, and John Groopman for helpful discussions.

Edmundo Torres-González, BS[1]
Laboratory of Translational Genomics
Division of Cancer Epidemiology and Genetics
NCI, Gaithersburg, MD

Griselda López, MD[1]
Department of Gynecology and Obstetrics
Hospital General San Juan de Dios
Guatemala City, Guatemala

Britton Trabert, PhD[1]
Metabolic Epidemiology Branch
Division of Cancer Epidemiology and Genetics
NCI, Gaithersburg, MD

Victor Argueta, MD
Department of Pathology
Hospital San Juan de Dios
Guatemala City, Guatemala

Eduardo Gharzouzi, MD
Integra Cancer Institute
Guatemala City, Guatemala

Michael Dean, PhD
Laboratory of Translational Genomics
Division of Cancer Epidemiology and Genetics
NCI, Gaithersburg, MD
deanm@mail.nih.gov

Roberto Orozco, MD
Department of Pathology
Hospital San Juan de Dios
Guatemala City, Guatemala

[1]These authors contributed equally to this article.

The authors report no conflicts of interest.

Supported in part by the Intramural Research Program of the National Institutes of Health, National Cancer Institute, Center for Cancer Research, and Leidos-Frederick under contract #HHSN261200800001E. The content of this publication does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the U.S. government.

**REFERENCES**

**1.** Torres-Gonzalez E, Lopez G, Trabert B, et al. High prevalence of precocious menarche in Puerto Barrios, Guatemala: BioRxiv; 543090v1. 2019.
**2.** Anderson SE, Must A. Interpreting the continued decline in the average age at menarche: results from two nationally representative surveys of U.S. girls studied 10 years apart. J Pediatr 2005;147:753–60.
**3.** Thomas F, Renaud F, Benefice E, de Meeus T, Guegan JF. International variability of ages at menarche and menopause: patterns and main determinants. Hum Biol 2001;73:271–90.
**4.** Alvarez T. Atencion Hospitalaria del Parto y Aborto en Adolescentes Embarazadas antes de los 14 Anos. Guatemala City: Universidad San Carlos de Guatemala; 2013.
**5.** Orozco Vasquez I. Edad de la menarquia en la poblacion Guatemalteco. Guatemala City: Universidad de San Carlos de Guatemala; 1999.
**6.** Torres OA, Palencia E, Lopez de Pratdesaba L, et al. Estimated fumonisin exposure in Guatemala is greatest in consumers of lowland maize. J Nutr 2007;137:2723–9.

 https://doi.org/10.1016/j.ajog.2019.03.013

# Prediction of mode of delivery using the first ultrasound-based "intrapartum app"



**OBJECTIVE:** Although characteristics of labor leading to a higher likelihood of cesarean delivery are now better described,[1] changing intrapartum practice has not translated into reduced cesarean delivery rates.[2] Ultrasound, despite its promise in facilitating noninvasive assessment in labor, remains largely confined to determining fetal malposition

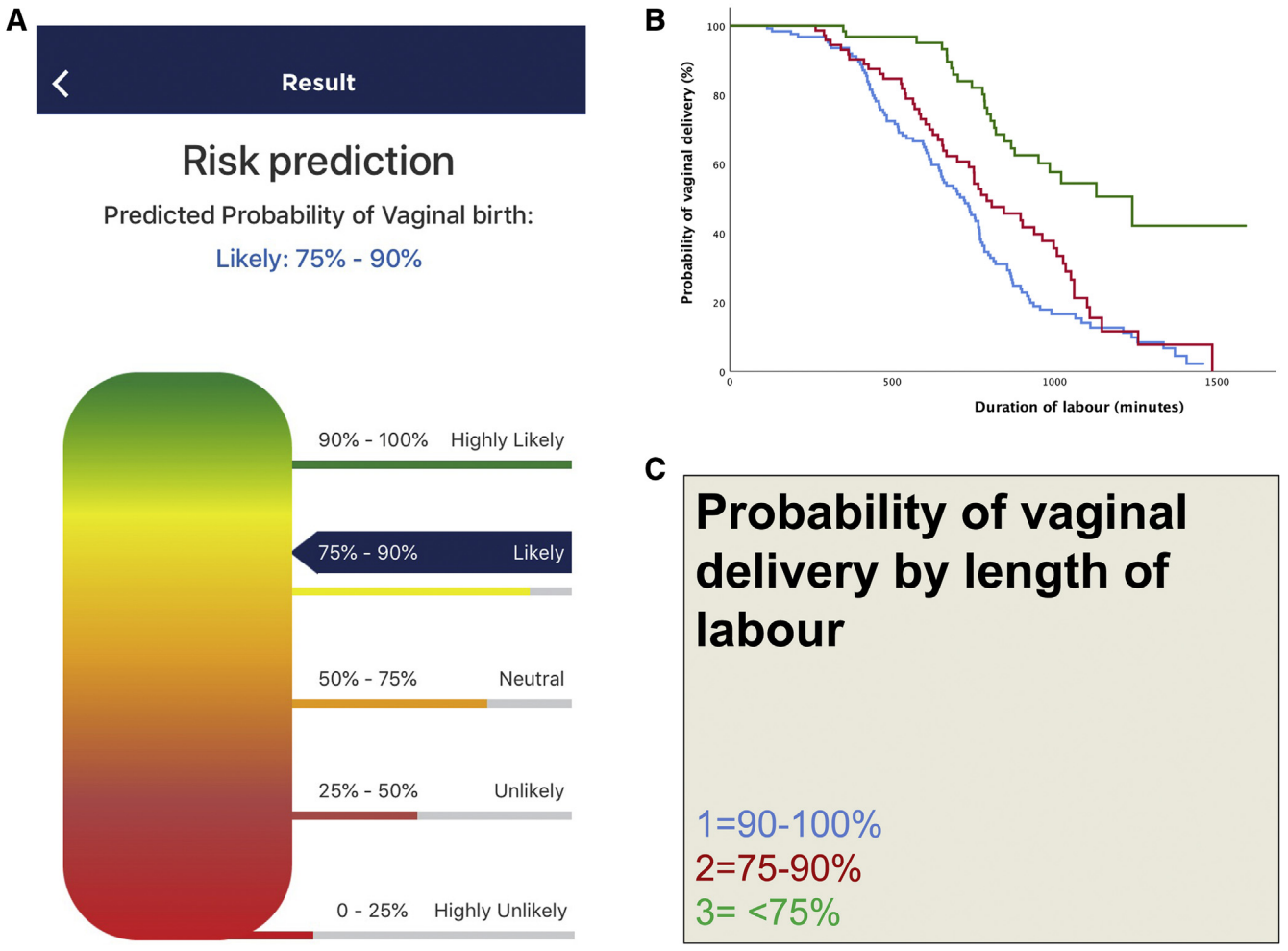
**TABLE**
**Estimated duration and probability of vaginal delivery subdivided according to predicted likelihood of vaginal delivery**

| | Highly likely (high) | | Likely and neutral (medium) | | Unlikely (low) | |
|---|---|---|---|---|---|---|
| Probability of vaginal delivery category | Observed | Expected | Observed | Expected | Observed | Expected |
| Estimated duration of labor (min) | 721 | — | 791 | — | 1239 | — |
| % Vaginal delivery | 84.8 | 90-100 | 72.2 | 75-90 | 39.7 | <75% |

*Usman. Intrapartum app. Am J Obstet Gynecol 2019.*

and presentation.[3] The first labor prediction model based on intrapartum ultrasound was published in 2014 from a population of 120 women in 2 European maternity hospitals.[4] In 2017, based on this prediction model, the "intrapartum app" was launched (for research purposes only) on Apple and Android mobile devices.[5,6] We explore

**FIGURE**
**Risk prediction of vaginal delivery**




(**A**) "Intrapartum app" results page showing the prediction of the likelihood of vaginal birth. (**B**) Kaplan—Meier curves comparing the probability of being undelivered as per the app. Group 1: 90—100% indicates highly likely; group 2: 75—90% indicates likely; group 3: <75% indicates neutral to unlikely. (**C**) Probability box: percentage of women who have not had a vaginal delivery.

*Usman. Intrapartum app. Am J Obstet Gynecol 2019.*

the applicability of this prediction model in app format in a different obstetric population.

**STUDY DESIGN:** Nulliparous women at 37−42 weeks' gestation were recruited in active labor to a prospective study on intrapartum ultrasound and labor outcome, "The SONO-VE" study. Transabdominal ultrasound scans were used to assess fetal head position and transperineal scans to assess fetal head station using head−perineum distance and caput succedaneum. Cervical dilatation was recorded from the corresponding digital vaginal examination. Maternal and labor parameters including maternal age, body mass index, and presence or absence of prolonged labor[7] were recorded on the app. The published model defined vaginal delivery as 90−100% highly likely, 75−90% likely, 50−75% neutral, 25−50% unlikely, and 0−25% highly unlikely.[4] Kaplan−Meier curves were constructed comparing the likelihood of vaginal delivery within 3 simplified likelihood bands ("highly likely," "likely and neutral," or "unlikely," classified as "high," "medium," and "low" likelihood, respectively).

Data was anonymized and entered into a Microsoft Excel spreadsheet prospectively at the time of ultrasound and first digital vaginal examination. To prevent any potential for bias in clinical management, these data were entered by the research team at a time and place remote from the delivery suite into the app without knowledge of delivery outcome.

The study received UK Ethical approval from the Research Ethics Committee (REC) approval (Reference: 15/LO/0227) and local Joint Research Compliance Office approval (Ref: 14HH2428) for "The SONO-VE study." The project was adopted by the NIHR portfolio (Ref: 163370).

**RESULTS:** From April 2015 to January 2018, data from 270 women, of whom 1 woman withdrew consent, were consecutively entered into the "intrapartum app." Of the remaining patients, 29% (79/269) had an emergency cesarean delivery. When censoring for those patients who had cesarean deliveries, the length of labor was shorter for those patients predicted to be at high likelihood of vaginal delivery (≥75%) (Table, Figure). In the "high" likelihood group, the estimated median duration was 721 minutes (95% confidence interval [CI], 641−801) with 84.8% (106/125) vaginal deliveries. In the "medium" likelihood of vaginal delivery group, the estimated duration was 791 minutes (95% CI, 664−918) with 72.2% (52/72) vaginal deliveries. In the "low" likelihood group, the estimated median duration was 1239 minutes (95% CI, 917−1561) with 39.7% (25/63) vaginal deliveries. There was a significant difference in duration among groups (log rank test, $P < .01$) and significantly fewer vaginal deliveries in the "low" likelihood group ($\chi^2$ test, $P < .01$).

**CONCLUSION:** This first report of an "intrapartum app" suggests that it predicts vaginal delivery in a new obstetric population from that in which the original model was developed. The acceptability and accuracy of this model can now be tested in a prospective study. ■


## ACKNOWLEDGMENTS

We thank "Apps Only" (http://www.appsonly.net/en/) for developing this app with our team. We thank the patients for participating in this study, which was conducted in an acute setting at a particularly sensitive time.


## AUTHOR CONTRIBUTIONS

SU was responsible for writing and submitting the manuscript. CL, Sana Usman, HB, and CW-B designed the study and the "Intrapartum App" and recruited the patients. CL, SU, WH, CW-B, TE, BK, KS were involved in developing the original labor prediction model. All authors contributed to the analysis, writing, and review of the manuscript.


Sana Usman, MD, MRCOG
Department of Cancer and Surgery
Imperial College London
London, UK
Centre for Fetal Care, Queen Charlotte's and Chelsea Hospital
Imperial College Healthcare NHS Trust
London, UK

Birgitte Heiberg Kahrs, MD
National Center for Fetal Medicine
St Olavs Hospital, Trondheim University Hospital
Trondheim, Norway
Department of Clinical and Molecular Medicine
Norwegian University of Science and Technology
Trondheim, Norway

Charlotte Wilhelm-Benartzi, PhD
Wales Cancer Trials Unit Centre for Trials Research
College of Biomedical & Life Sciences, Cardiff University
Cardiff, South Glamorgan, UK

Wassim A. Hassan, MD, PhD
Fetal Medicine Unit
Colchester Hospital University NHS Foundation Trust
Colchester General Hospital Trust Offices
Colchester, Essex, UK

Helen Barton, BSc
Department of Cancer and Surgery
Imperial College London
London, UK
Centre for Fetal Care
Queen Charlotte's and Chelsea Hospital
Imperial College Healthcare NHS Trust
London, UK

Kjell A. Salvesen, MD, PhD
National Center for Fetal Medicine
St Olavs Hospital, Trondheim University Hospital
Trondheim, Norway
Department of Clinical and Molecular Medicine
Norwegian University of Science and Technology
Trondheim, Norway

Torbjorn Moe Eggebø, MD, PhD
National Center for Fetal Medicine
St Olavs Hospital, Trondheim University Hospital

Trondheim, Norway
Department of Clinical and Molecular Medicine
Norwegian University of Science and Technology
Trondheim, Norway

Christoph Lees, MD, FRCOG
Department of Cancer and Surgery
Imperial College London
London, UK
Centre for Fetal Care
Queen Charlotte's and Chelsea Hospital
Imperial College Healthcare NHS Trust
London, UK
Department of Development & Regeneration
KU Leuven
Leuven, Belgium
Christoph.lees@nhs.net

The authors report no conflict of interest.

CL is supported by the National Institute for Health Research (NIHR) Biomedical Research Centre based at Imperial College Healthcare NHS Trust and Imperial College London. SU has been funded by the British Medical Association (Helen Lawson Grant), Imperial Confidence in Concept and Imperial College Healthcare NHS Trust. HB was supported by Imperial College Healthcare Charities. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

## REFERENCES

**1.** Grobman WA, Bailit J, Lai Y, et al. Eunice Kennedy Shriver National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. Defining failed induction of labor. Am J Obstet Gynecol 2018;218:122.

**2.** Bellussi F, Ghi T, Youssef A, et al. The use of intrapartum ultrasound to diagnose malpositions and cephalic malpresentations. Am J Obstet Gynecol 2017;217:633–41.

**3.** Thuillier C, Roy S, Peyronnet V, Quibel T, Nlandu A, Rozenberg P. Impact of recommended changes in labor management for prevention of the primary caesarean delivery. Am J Obstet Gynecol 2018;218:341.

**4.** Eggebø TM, Wilhelm-Benartzi C, Hassan WA, Usman S, Salvesen KA, Lees CC. A model to predict vaginal delivery in nulliparous women based on maternal characteristics and intrapartum ultrasound. Am J Obstet Gynecol 2015;213:362.

**5.** Intrapartum - Apps on Google Play. 2018. Available at: https://play.google.com/store/apps/details?id=be.appsonly.intrapartum&hl=en. Accessed November 13, 2018.

**6.** Intrapartum on the App Store. 2017. Available at: https://itunes.apple.com/us/app/intrapartum/id1191439521?mt=8. Accessed November 13, 2018.

**7.** Intrapartum Care for Healthy Women and Babies. NICE Clinical Guideline 190. 2014. National Collaborating Centre for Women's and Children's Health (UK). Available at: https://www.nice.org.uk/guidance/cg190. Accessed November, 13, 2018.

 https://doi.org/10.1016/j.ajog.2019.03.019