Constructing Normalcy and Discrepancy Indexes from Birth Weight and Gestational Age Using a Threshold Regression Mixture Model

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Abstract

Birth weight and gestational age are important measures of a newborn's intrinsic health, serving both as outcome measures and explanatory variables in health studies. The measures are highly correlated but occasionally inconsistent. We anticipate that health researchers and other scientists would be helped by summary indexes of birth weight and gestational age that give more precise indications of whether the birth outcome is healthy or not. We propose a pair of indexes that we refer to as the birth normalcy index or BNI and birth discrepancy index or BDI. Both indexes are simple functions of birth weight and gestational age and in logarithmic form are orthogonal by construction. The BNI gauges whether the birth weight and gestational age combination are in a normal range. The BDI gauges whether birth weight and gestational age are consistent. We present a three-component mixture model for BNI, with the components representing premature, at-risk, and healthy births. The BNI distribution is derived from a stochastic model of fetal development proposed by Whitmore and Su (2007, Lifetime Data Analysis 13, 161–190) and takes the form of a mixture of inverse Gaussian distributions. We present a noncentral t-distribution as a model for BDI. BNI and BDI are also well suited for making comparisons of birth outcomes in different reference populations. A simple z-score and t-score are proposed for such comparisons. The BNI and BDI distributions can be estimated for births in any reference population of interest using threshold regression.

Keywords: Fetal development; Healthy birth outcome; Inverse Gaussian distribution; Mixture model; Stopping time; Wiener process.

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