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Apgar Score and Infant Mortality in Puerto Rico

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ABSTRACT. This study has as its objectives: 1) to examine the association between Apgar score and a set of demographic and sociodemographic variables so as to assess its usefulness as an indicator of the physical conditions of the newborn; 2) to determine if Apgar score in Puerto Rico is a good predictor of the newborn probability of surviving during his first year of life. For this purpose the 1990 live births and infant deaths data was utilized. The results indicate a direct relation between Apgar score with mother's schooling, father's occupation, and number of prenatal visits. Apgar score shows, also, an *U* curve type relationship with birthweight and gestational age, while it was found to be higher in private than in public hospitals. One of the most important findings was the strong association between infant mortality and Apgar score, even when the effect of other important independent variables such as birthweight and gestational age were held constant. These results demonstrate that, in spite of its criticisms Apgar score seems to be an excellent indicator of the newborn conditions at birth and a very good predictor of infant mortality in Puerto Rico. *Key words: Apgar score, Prenatal care, Infant birthweight, Infant gestational age, Infant mortality.*

The Apgar score was introduced in 1952, 1) to provide an assessment of the infant condition at his first minute of life as well as its response to different methods of resuscitation, 2) to provide a method both within and between hospitals for comparisons of the effects of disease and treatment in the newly born infant, 3) to predict survival of the new born infant, and, 4) to encourage among clinicians increased concern for, and interest in the newly-born infant throughout the first few minutes of the extra-uterine existence (1-3). Later on, Drage, et al. recommended that it also be taken at five minutes of life, a practice that have been accepted (4).

The Apgar score varies between a minimum value of zero to a maximum of ten obtained through the observation of five signs of life: heart rate, respiratory effort, muscle tone, reflex irritability and color (1). Newborn infants are usually grouped into three categories according to their ratings: severely depressed (0-3), moderately depressed (4-6) and good to excellent physical conditions (7-10). Sometimes the group with 7-10 scores is subdivided into good (7-8) and excellent (9-10) conditions.

It has been claimed that the one minute assessment is an indication of the newborn's condition at birth while the five minutes value reflects a combination of the infant's condition at birth and the care received during his first five minutes of life (5).

The Apgar score has been criticized regarding its data validity and its objectives or functions. Data criticism claims that because of the lack of an instrument to measure the score, the results will depend on who assigns it and on the circumstances under which the score is taken. The obstetrician for example, usually gives higher scores than the other members of the delivery team (3). Another critique argues that the score is assigned mainly based on experience, and as a result, a separate evaluation of the different components of the system is not undertaken. This is specially true regarding one minute Apgar score.

According to Crawford et al. (6), each of the objectives of the Apgar score has, to a variable extent, "been demonstrated to be attainable." The fourth objective mentioned, has been the mayor triumph of the system since it was the introduction of the Apgar system that gave impulse to the intensive interest exhibited internationally in the newborn infant.

Opinions and findings regarding the other three objectives of the score have varied (6). The predictive function of the scoring system, which is of particular interest in this research, has aroused considerable attention and has proved to be of some value specially in relation to the immediate outcome. Empirical evidence from some studies have confirmed this predictive function, specially among neonates (1,2,3,6). Some of these studies, however, have not shown this finding to be straightforward.

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Infants with a high Apgar score, for example, might afterward develop physical impairment, while those with low Apgar score might have normal neurological functioning (7). Other studies indicate that even though low Apgar score suggests intrapartum asphyxia, this condition can be the result of factors such as maternal sedation, smoking trauma, infection, laryngeal reflex inhibition of breathing, muscle disease and developmental brain abnormalities. It might be difficult to decide which of these factors is most important in causing a depressed Apgar score (7).

Given that the Apgar score indicates the birth health conditions and is a possible predictor of its first year survival probability, it is expected that this score is closely related with prenatal care characteristics of the newborn and mother's socio-economic conditions, as well as with infant mortality.

Empirical evidence from the United States shows consistent and expected relations between Apgar score distribution with some demographic and socio-economic indicators and with infant mortality. Infants born to mothers at the extremes of the childbearing ages, as well as those at the extreme of the weight scale, for example, have low Apgar scores (5).

Knowledge about the magnitude and direction of these relations will contribute to identify the determinant factors of the newborn condition and of infant mortality. This knowledge will provide empirical basis for the development of adequate health policies in this respect. Besides, if these relationships are consistent with what is expected, the validity of the Apgar data will be indirectly assessed.

Although this evaluation system began to be used in some hospitals in Puerto Rico a few years after Apgar's recommendation, and in spite of the extensive and intensive attention which it has received at the international level (5-23), the authors have been unable to find at least a single study dealing with the Apgar score, its associated factors and its predictive value. Items about the one minute and five minutes scores were introduced into Puerto Rico's live birth certificate in 1978, but such data began to be published in 1979 (24). Although the results obtained for that year were similar to those recorded in the United States in 1978 (5), the high proportion of "non-response" in the birth certificates of Puerto Rico (11 percent for the one minute and 12 percent for the five minutes) makes the comparison somewhat uncertain. Since then, the "non-response error" has been reduced considerably (0.3 percent in 1990). Although at present the data seems to be relatively accurate at first glance, there still exists doubts as to the degree of preciseness in assigning the score. An analysis of the relationships between Apgar score with specific socio-demographic and maternal care variables and the consistency shown by these associations will indicate in an indirect way its reliability.

In an intent to clarify this, the main objectives of this study are:

1. To uncover the relationships between Apgar score to some demographic and socioeconomic characteristics of the mother, the adequacy of the prenatal care received, pregnancy and delivery complications, and infant's birthweight and gestational age. If similar relationships as those found in other countries appear, the reliability of the score is confirmed as well as its usefulness as an indicator of the pregnancy outcome.

2. To determine if the Apgar score in Puerto Rico is a good predictor of the newborn probability of surviving his first year of life.

Methods

The data utilized in this study was derived from a file of the 1990's birth certificates (computer tape) obtained from the Department of Health of Puerto Rico. In the analysis of the relationship between Apgar score and infant mortality, the file of the 1990 live birth cohort in which data about the corresponding infant deaths included, was used.

Simple analytic techniques such as percent distributions, proportions and death ratios were utilized in this study. Infant death ratios differ slightly from the conventional infant death rates as they are based on a cohort experience. For this reason, infants dying in Puerto Rico but born elsewhere (any place outside Puerto Rico) were not considered, whereas they are included in the conventional infant death rates. Ratios are expressed in per 1,000 live births in the case of neonatal and total infant mortality and in per 1,000 neonatal survivors in the case of late infant mortality.

Results

According to the 1990 data, one percent of the newborn infants was in an extremely depressed condition at the first minute of life. Almost four percent was considered moderately depressed and 12 percent was evaluated in excellent conditions (9 and 10) (Table 1). These figures changed considerably between the one minute and the five minutes assessment. The most striking change was the increment in the proportion of newborns considered in excellent physical conditions; an increase from 12 percent to 91 percent. The same trend is observed among infants born in private hospitals as well as among those born in public institutions, although newborns delivered in private settings have higher scores than those born in public hospitals.

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Table 1
Percent distribution of newborn according to the one and five minutes Apgar scores
and type of hospital in which the delivery took place Puerto Rico, 1990

Apgar Score	All Hospitals*		Private Hospitals		Public Hospitals	
	One minute	Five minutes	One minute	Five minutes	One minute	Five minutes
0 - 3	1.1	0.4	0.5	0.2	1.6	0.6
4 - 6	3.3	1.0	1.5	0.3	4.4	1.4
7 - 8	83.3	7.2	77.9	4.5	86.7	8.9
9 - 10	12.3	91.4	20.1	95.0	7.3	89.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
Number of Live Births	66,326	66,326	25,496	25,496	40,830	40,830

* Excludes infants born outside hospitals.

The radical change in the percentage of newborn considered in excellent conditions from the one minute to the five minutes evaluation was due to an enormous score's increase from 8 to 9. According to the 1990 data, 97 percent of the newborns with an eight score in the one minute evaluation experienced such a change. This striking increase, has also been observed in the United States (5).

Correlates of Apgar score. In this section, the authors considered only the five minutes score as it has been claimed that it is a better predictor of the newborn's chances of survival than the one minute (5,1). However, much similar relationships were found with respect to the one minute score. Mother's age showed a weak association with her newborn's five minutes score although the proportion of infants classified in excellent physical conditions (9-10 scores) presented a curvilinear relationship; those of mothers with 25-34 years of age having the highest percentage. The highest figures of depressed newborns (0 to 6 scores) were recorded among infants of adolescent mothers and among those of 35 years of age and older.

A similar association was observed between the five minutes Apgar score and mother's parity. Primiparae and high parity (4 or more) mothers had the highest percentages of depressed newborns and the lowest percentages of infants considered in excellent conditions. Mother's marital arrangement was closely associated with their newborns' conditions. Infants of legally married mothers had the highest Apgar scores whereas those of unwed ones had the lowest.

Mother's schooling was directly associated with their newborns physical state; as mother's number of years of school completed increased, the proportion of depressed infants (0-6) declined whereas the percentage evaluated in excellent conditions increased (Table 2).

One of the most significant associations was observed between the newborn's Apgar score and the number of prenatal visits made by his mother (Table 3). The percent of depressed newborns, both severely and moderate,

decreased as the number of prenatal visits made by the mother increased whereas the proportion assessed in excellent conditions showed a direct association. Contrary to what should be expected, the trimester of pregnancy in

Table 2
Percent distribution of newborns by broad groups of five minutes Apgar score and selected demographic and socioeconomic variables, Puerto Rico, 1990

Variable	FIVE MINUTES APGAR SCORE				Number of Live Births*
	0 - 3	4 - 6	7 - 8	9 - 10	
Mother's age					
17 or less	0.4	1.5	9.9	88.2	5,338
18-19	0.4	0.9	8.5	90.2	7,128
20-24	0.4	0.9	7.1	91.6	21,272
25-29	0.4	0.8	6.4	92.3	18,407
30-34	0.5	1.0	6.8	91.7	9,725
35 and over	0.5	1.2	6.9	91.4	4,467
Mother's parity					
One	0.4	1.1	8.1	90.4	26,113
Two	0.4	0.8	6.3	92.5	20,043
Three	0.4	0.9	6.3	92.4	11,797
Four	0.7	1.1	7.7	90.5	4,621
Five or more	0.6	1.4	8.0	90.0	3,777
Mother's marital arrangement					
Legally married	0.3	0.8	6.7	92.2	41,975
Consensually married	0.6	1.1	8.2	90.1	18,640
Unwed	0.7	1.4	8.3	89.6	5,717
Mother's years of school completed					
0 - 6	0.7	1.7	9.1	88.5	3,309
7 - 11	0.6	1.2	8.7	89.5	18,851
12	0.4	0.9	7.4	91.3	18,898
13 -15	0.4	0.8	6.1	92.7	14,530
16 and over	0.3	0.6	5.2	93.8	10,666

* The number of live births in each row represents 100 percent and excludes "not reported".

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which mother's prenatal care began showed no association with her newborn's Apgar score. In fact, the lowest proportion of depressed infants corresponded to those whose mothers began the care in the second trimester of pregnancy.

The Kessner index (25), which combines the number of prenatal visits and month of pregnancy in which the care began with the weeks of pregnancy at the outcome to assess the adequacy of the care, showed a clear relationship with the Apgar score; as the level of adequacy increased the score increased (Table 3).

Pregnancy and labor complications were found to be closely related to the newborn's physical condition. Those infants whose mothers had no complications had the lowest proportion of depressed newborns and the highest percentage of newborns in apparently excellent conditions. On the other hand, the poorest performance corresponded to those whose mothers had pregnancy and delivery complications. The figures on Table 3 tend to demonstrate that delivery complications had a more

depressing effect than pregnancy problems.

As expected, birthweight and gestational age were closely associated with Apgar score. The five minutes rating increased as birthweight increased but among heavyweight newborns there was a slight decline (Table 4). A similar relationship was observed with gestational age.

When birthweight and gestational age were combined a clear-cut association emerged. Newborns who were both low birthweight and preterm had a very high proportion of depressed infants and a very low percentage in excellent physical conditions (Table 4). To be low birthweight seems to have more influence in the condition of the newborn than to be preterm.

Table 3
Percent distributions of newborns by broad groups
of five minutes Apgar score by prenatal care variables,
and pregnancy and delivery complications
Puerto Rico, 1990

	FIVE MINUTES APGAR SCORE				Number of Live
Variable	0 - 3	4 - 6	7 - 8	9 - 10	Births*
Number of prenatal visits					
0	3.4	2.8	11.9	81.9	783
1-3	2.2	2.7	10.4	84.7	2,256
4-6	0.9	2.1	8.8	88.2	9,957
7-9	0.4	0.9	8.2	90.5	16,862
10 or more	0.2	0.5	6.0	93.3	36,433
Trimester Prenatal care began					
First	0.4	1	7	91.6	47,041
Second	0.3	0.9	7.6	91.2	15,933
Third	1.2	1.2	8.5	89.2	3,129
Adequacy of Prenatal Care (Kessner Index)					
Inadequate	1.1	1.4	8.8	88.8	6,048
Intermediate	0.4	1	7.9	90.7	24,367
Adequate	0.4	0.9	6.5	92.3	35,682
Pregnancy and delivery complications					
No complications	0.2	0.4	5.6	93.9	43,104
Only pregnancy	0.5	1	7.7	90.9	6,405
Only delivery	0.8	1.9	10.2	87.2	11,834
Both complications	2.0	3.9	14.4	79.7	4,639

* The number of live births in each row represents 100 percent and excludes "not reported".

Table 4
Percent distributions of newborns by broad groups of
five minutes Apgar score by birthweight and gestational age
Puerto Rico, 1990

	FIVE MINUTES APGAR SCORE				Number of Live
Variable	0 - 3	4 - 6	7 - 8	9 - 10	Births*
Birthweight (in grams)					
1500 or less	20.1	29.4	32.6	18	763
1501 - 2000	2.7	7.1	35.9	54.3	1,054
2001 - 2500	0.7	2.1	15.4	81.8	4,205
2501 - 3000	0.2	0.6	7	92.2	15,678
3001 - 3500	0.1	0.4	5.2	94.3	27,266
3501 - 4000	0.1	0.4	5.4	94.1	14,075
4001 and over	0.0	0.4	7.5	92.1	3,178
Weeks of gestation					
36 or less	2.7	4.9	16.3	76.1	7,501
37	0.1	0.5	7.3	92.1	5,892
38	0.1	0.4	5.2	94.3	11,396
39	0.1	0.3	5.3	94.3	15,561
40	0.1	0.5	5.9	93.5	14,436
41	0.2	0.7	7.5	91.6	7,097
42 and over	0.3	0.8	7.6	91.2	4,286
Low birthweight or preterm**					
Nor low birthweight nor preterm	0.1	0.4	5.7	93.8	55,902
Only preterm	0.3	0.7	8.1	90.8	4,238
Only low birthweight	0.9	1.8	14.2	83.1	2,752
Low birthweight and preterm	5.6	10.4	27.0	57.0	3,257

* The total number of live births in each row equal 100 percent and excludes "not reported".

** Low birthweight, 2,500 grams or less; preterm, 36 weeks of gestation or less.

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To determine if Apgar score was a function of other variables such as the newborn birthweight and gestational age a simple linear regression analysis was undertaken in which the five minutes score, the dependent variable, was arbitrarily considered as a quantitative variable (interval). The simple correlation coefficients obtained demonstrate that out of 12 independent variables considered, only weeks of gestation, type of hospital in which the delivery took place, number of prenatal visits made by the mother and birthweight showed relatively strong relationships with Apgar score (Table 5). However, when a multiple regression analysis was undertaken, only weeks of gestation and type of hospital in which the delivery took place had partial correlation coefficients of relative importance. Thus, this analysis demonstrated that Apgar score is an independent indicator which has little to do with birthweight. The partial correlation coefficient obtained between five minutes Apgar score and birthweight controlling the other three variables was only 0.024.

Table 5
Simple and partial correlation coefficients between five minutes Apgar score (dependent variable) and the four most important independent variables
Puerto Rico, 1990

Independent variables	Correlation coefficients	
	Simple*	Partial**
Weeks of gestation	0.264	0.258
Type of hospital (private = 1, public = 0)	0.129	0.129
Prenatal visits	0.121	0.035
Birthweight in grams	0.110	0.024

* The simple correlation coefficient between the dependent variable (Apgar score) and the indicated independent variable.

** The correlation coefficient between the dependent variable (Apgar score) and the indicated independent variable controlling the effects of the other three independent variables.

Apgar Score and Infant Mortality. The 1990 data showed that infant mortality was closely associated with the newborn's five minutes Apgar score. This was true both for neonatal as well as for late infant mortality. As shown on Table 6, infant mortality ratios declined rapidly and consistently as the Apgar score increased. Although not included in this study, similar trends were observed between the one minute Apgar score and infant mortality.

To determine whether the relationship between Apgar score and infant mortality was due to the close relationship between this score and newborn's birthweight and gestational age, cross-tabulations were utilized (contingency analysis). The results presented on Table 7 indicate that the five-minute Apgar score had an independent strong relationship with infant mortality. It is clearly demonstrated that in all the birthweight and gestational

Table 6
Infant mortality ratios by five minutes Apgar score
Puerto Rico, 1990

Apgar score	Neonatal*	Late infant**	Total*
0 - 3	612.2	105.3	653.1
4 - 6	259.3	83.9	321.4
7	71.4	28.5	97.9
8	19.6	6.8	26.2
9	2.5	1.8	4.3
10	1.8	1.2	3.0

* Number of infant deaths per 1,000 live births.

** Number of infant deaths 28 days of life and more per 1,000 neonatal survivors.

Table 7
Neonatal mortality ratios by five minutes Apgar score
by birthweight and by gestational age
Puerto Rico, 1990

	FIVE MINUTES APGAR SCORE			
	0 - 3	4 - 6	7 - 8	9 - 10
Birthweight in grams				
1500 or less	830.1	497.8	276.0	131.4
1501 - 2500	370.4	226.7	68.8	17.5
2501 - 3000	400	113.6	23.2	8.4
3001 - 4000	346.7	103.7	8.2	1.6
4000 or more	*	166.7	8.4	1.7
Weeks of gestation				
36 or less	712.9	369.3	85	9.1
37 - 38	250	129	16.3	2.6
39	200	71.4	14.4	1.5
40	421.1	120	2.4	1.4
41 and more	580.6	122.0	11.5	1.3

*Few live births in this category.

age categories neonatal mortality declined consistently as Apgar score increased.

Discussion

In this study the association between Apgar score and a set of independent variables included in the Puerto Rico's live birth certificate was examined. The five-minute score behaved as expected with almost all the demographic and socio-economic variables considered.

With respect to prenatal care, Apgar score was clearly and directly associated with the number of prenatal visits but did not behave as expected in relation to the trimester of pregnancy in which the care began. In this case, newborns of mothers who began the care in the first trimester did not have higher scores than those mothers

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who began the care in the second trimester. This peculiar relationship has been observed since 1984, the first year for which the authors have been able to analyze these data. It seems that if prenatal care does not begin too late (e.g. third trimester of pregnancy) the month of pregnancy in which it is initiated has at present little to do with the outcome. In Sweden, for example, 98 percent of the mothers began this care in the first trimester whereas in Japan the corresponding figure was 50 percent (26). But in spite of this difference Japan has the lowest infant mortality rate of the World and Sweden a slightly higher.

The 1990 data showed, as expected, that low birthweight and heavy birthweight newborns had the lowest Apgar scores. A similar relationship was observed with respect to gestational age. On the other hand, infants born in private hospitals were in better physical health conditions at birth than those delivered in public facilities. As the 1990 data demonstrate, this difference was due mainly to socio-demographic differences between the two clientele. The majority of adolescent and unwed mothers as well as those of the lowest socioeconomic level had their deliveries in public hospitals whereas the opposite is true for private institutions (27). In addition, the quality of this care is claimed to be better in private settings than in public ones.

One of the most important findings of this study was the strong negative association between infant mortality and Apgar score, even when the effect of other important independent variables such as birthweight and gestational age were held constant. In an unpublished study Vázquez-Calzada found that Apgar score is the best predictor of neonatal mortality in Puerto Rico.

The results of this study tend to demonstrate that Apgar score is an adequate indicator of the newborn's condition at birth and a very good predictor of infant mortality, specially of neonatal mortality. If the results of this score are mainly determined by human factor, as it has been argued, it would have been expected irregular associations between Apgar score with the socio-demographic variables analyzed. This was not the case. Thus, if Apgar score assessment is not carried out by some physicians as indicated, a criticism that the authors have heard many times, its improvement would undoubtedly increase its power of predictability of the newborn's probability of dying during his first year of life. It would also be a much better indicator of the newborn's physical condition at birth. It must be recognized that Apgar score is not a perfect index but it cannot be accepted that it is such a poor measure as some health scientists have concluded (8). If such assertion were true we will be facing a perplexing scientific enigma; how it is, that such and unreliable measurement can be such a good predictor of first year survival as evidenced by almost all studies and almost everywhere?

Resumen

Este estudio tiene como objetivos: 1) examinar la asociación entre el valor Apgar y un grupo de variables demográficas y socioeconómicas para evaluar su utilidad como indicador de la condición física del recién nacido, 2) determinar si el valor Apgar es un buen pronosticador de la probabilidad de sobrevivencia del recién nacido durante su primer año de vida. Para estos propósitos se utilizaron los datos de Puerto Rico correspondientes a los nacidos vivos en 1990, así como las muertes infantiles correspondientes a este cohorte de nacimientos. Los resultados indican una relación directa entre el valor Apgar y el nivel de instrucción de la madre, la ocupación del padre y el número de visitas prenatales. El valor Apgar muestra, además, una relación de tipo U con la edad y resulta ser más alta entre los nacidos vivos en hospitales privados que entre los nacidos en hospitales públicos. Un hallazgo importante de este estudio fue la fuerte relación negativa entre la mortalidad infantil y el valor Apgar, aún controlado el efecto de otras variables independientes como peso y edad gestación. Este estudio demuestra que a pesar de las críticas, el valor Apgar parece ser un excelente indicador de las condiciones físicas del recién nacido y un buen pronosticador de la mortalidad infantil en Puerto Rico.

Acknowledgement

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