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Statistical Classification of the State of Newborns in Burundi

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Abstract

This work aims to identify the various health districts in Burundi requiring more than others specific support for improving child health while applying the exploratory method. The latter consists in calculating, for the districts surveyed as part of the development of the statistical yearbook, indicators assessing the state of health of the newborns. For this end, a statistical classification was performed. These statistical analyzes use a set of data totaling 14 variables relating to the state of health of newborns.

Keywords: Neonatal, children, deaths, breastfeeding, stillbirths, newborn, Health District, Burundi.

1 Introduction

Neonatal mortality remains a current problem in Burundi. According to the data from 2009 to 2019, several diseases are the main causes of death of children in

Burundi. Farah et al. (2018) noted that Diarrheal diseases, malaria, neonatal disorders and HIV/AIDS are the leading causes of death. According to this study, the mortality number for children under 5 is decreasing from 240 deaths per 1,000 live births in 1965 to 60 in 2015. The risk of a child dying before age five in Burundi is almost 1.6 times higher than that observed by the World Health Organization African region (WHO, 2018). According to the UNICEF report (UNICEF, 2014), the same downward trend is observed globally, with the number of newborn deaths falling from 5 million in 1990 to 2.4 million in 2019. In his research, Liu et al. (2014) noted that neonatal mortality remains a major public health concern worldwide, Nearly 6.3 million children died before the age of 5 in 2013. Children are most at risk of death during the first 28 days of life. Women who benefit from continuity of care directed by qualified personnel have a lower risk of losing their child (evaluated at 16%) and of giving birth prematurely (evaluated at 24%) (WHO, 2012). The researches conducted by (Ahmed et al., 2023), (Owusu et al., 2018), (Fotso et al. 2020) and (Ijdit al., 2022) have shown that access to qualified staff during delivery can prevent maternal and early neonatal deaths.

Materials and methods:
To classify key elements determining the health situation in health districts in Burundi, we used data from the 2020 Health Statistics Yearbook of the National Health Information System. The data comes from monthly reports from health facilities (health centers, clinics, polyclinics, and hospitals) and community health worker groups. The National Health Information System Department is responsible for collecting, processing, analyzing, and disseminating health statistics. The variables considered are discrete quantitative: live births (N_viv), stillbirths (N_mort), total deliveries (TAC), full-term newborns < 2500g (N_sp), premature births (Prema), neonatal deaths within 24 hours (D24h), and women breastfeeding in the first hour (FAH). In this study, descriptive and exploratory statistics were used to present the data and transform correlated variables into principal components. Two analyses were performed: descriptive and multidimensional analysis. Data processing, analysis, and mapping were done using R software, version 4.1.1. The results are presented in tables and graphs, with a descriptive statistical analysis shown in figures.

2 Main Results

Descriptive analysis:
The dataset is composed of 7 variables. These variables take as numerical value the numbers recorded by each health district. The variables N_viv, N_mort, TAC are the number of births registered. The variables N_sp, Prema, D24h show the number for each state of the newborns. Finally, the variable FAH is the number of women breastfeeding their infants in the first hour after birth.

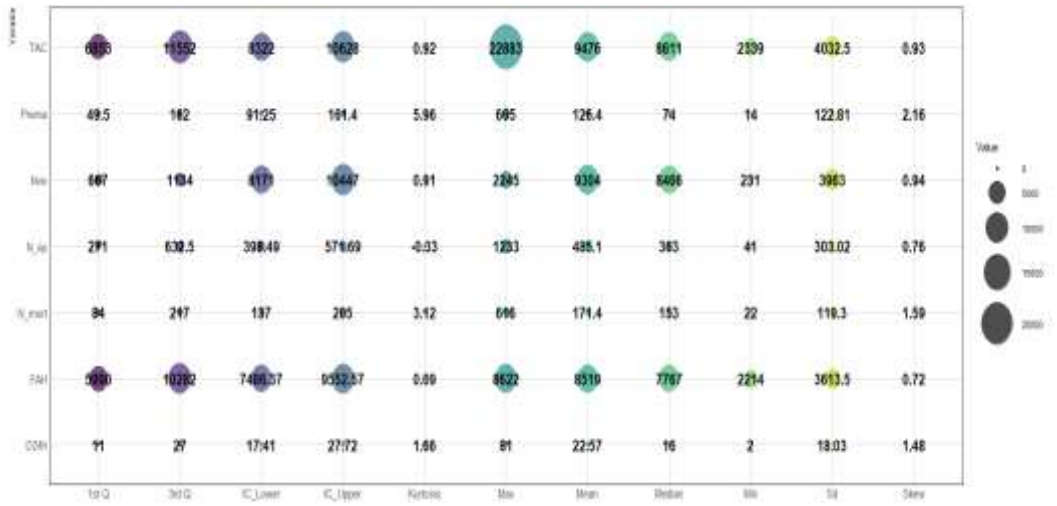

Figure 1. The descriptive statistical analysis

The bubble chart highlights the descriptive statistics of key maternal and neonatal health variables across 47 health districts, revealing substantial variability. For deliveries, the average number of births per district is 9,304, with live births representing 98.2% and stillbirths accounting for 1.78% on average. A quarter of districts report fewer than 6,853 deliveries (1st quartile), while stillbirths remain below 84 in 25% of districts. The average number of stillbirths per district is 171, with notable disparities across districts.

Newborn-related variables also exhibit significant differences. On average, 5.2% of newborns weigh less than 2,500 grams, amounting to 485 underweight newborns per district, and 1.3% of births are premature, with an average of 126 premature newborns per district. Neonatal deaths within 24 hours are relatively rare, with an average of 22 deaths per district (0.2%), but some districts report up to 81 such deaths. Additionally, the average number of breastfeeding women at childbirth is 8,519, with marked differences between districts, indicating disparities in healthcare access and outcomes. These findings underscore the need for focused healthcare interventions to address underweight newborns, premature births, and neonatal deaths in districts with the most severe outcomes, aiming to reduce disparities and improve overall maternal and child health.

Correlation matrix:

The correlation matrix below shows that certain variables are somehow related. Firstly, the variables N_viv and TAC representing respectively the variation of deliveries for registered live births and the variation of deliveries including stillbirths are correlated at 0. 99970. This correlation is explained by their method of calculation: N_viv contains all deliveries of live births while TAC contains deliveries of live births including stillbirths. For the rest of the analyses, only the N_viv variable will be kept.

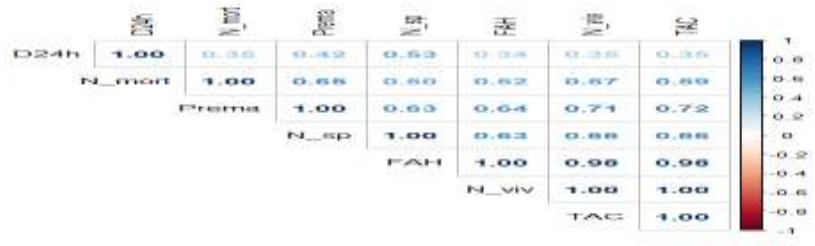

Figure 2. The correlation matrix of variables

Secondly, we find a correlation of 0.983 between the variables Births: live birth» and FAH number of women breastfeeding in the first hour». Although the correlation is higher than the fixed threshold of 0.90, we decided to keep these 2 variables for the rest of the analysis because they do not describe the same facts at all. We also notice several high and positive correlations such as for:
Prema and N_viv : « the number of preterm births» and « the number of deliveries for live births». This is logical since premature babies are included in live births
Prema and N_mort : « the number of preterm births» and «the number of deliveries for stillbirths »
N_viv and N_sp : « the number of deliveries for live births» and « the number of full-term newborns < 2500g ». This is logical since newborns with low birth weight are included in live births.

Principal Component Analysis:
The Principal Component Analysis (PCA) allows us to analyze multivariate data and visualize them as point clouds in geometric spaces. It allows us study the relationships between multiple variables in an exploratory way, which means when the exploitation of the data is not guided by any prior hypothesis. In addition, PCA makes it possible to position individuals, or groups of individuals, in relation to variables, and PCA offers the best possible visualization of multivariate data, by identifying the plane or planes in which the dispersion is maximum – thus highlighting with the maximum precision the relationships of proximity and distance between the variables.

Inertia: The variance explained by the first 2 axes is respectively 68% and 13.2% for a cumulative total of 81.2%. The 2 axes show more than 75% of the total inertia, which means that more than 75% of the information in the data table is contained in the first 2 dimension.

Description of axes. The plane is defined by dimensions 1 and 2 and represents the contribution of each variable on the axes. It allows us to make some conclusions about the variables.
Figure 3 presents also the variables and individuals (health districts) on the first two principal axes of the Principal Component Analysis (PCA). These axes explain 68% (F1) and 13.2% (F2) of the total variance, respectively, resulting in a cumulative

representation of 81.2%, which ensures a good quality of visualization. The variables N_viv and FAH are highly correlated, as indicated by their proximity and alignment on the graph. They are also well represented since their arrows are close to the correlation circle. Similarly, the variables N_sp and Préma show a strong correlation, whereas the variable D24h, which is more isolated, has a weaker correlation with the other variables but is well represented on the F2 axis.

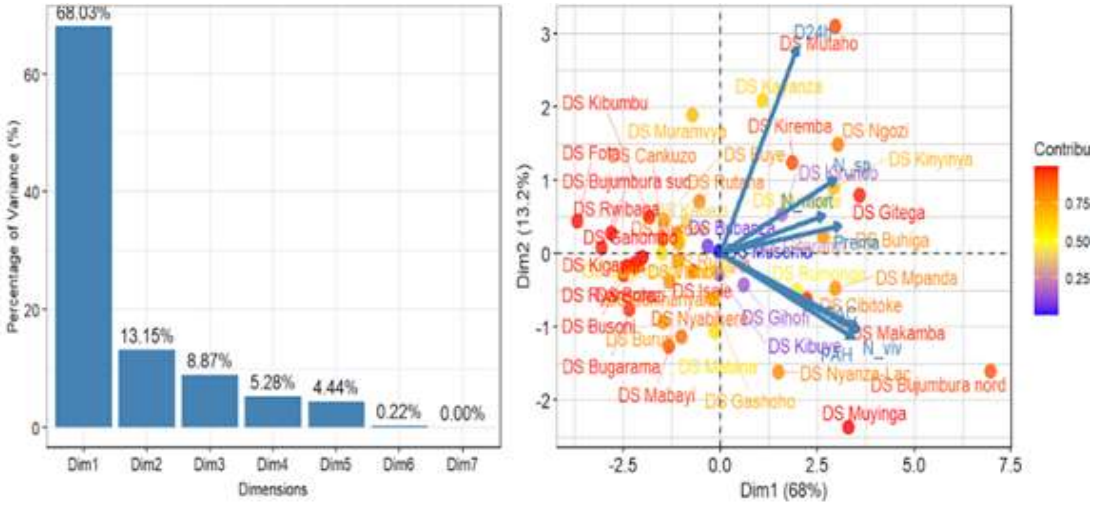

Figure 3. The explained variances and PCA Biplot

Regarding individuals, the graph reveals four distinct groups. Group I, composed of the districts DS Bujumbura Nord, DS Muyinga, DS Cibitoke, and DS Nyanza-Lac, stands out due to a high number of live births, breastfeeding women, and neonatal deaths. In contrast, Group II, including DS Mutaho, DS Kayanza, and DS Muramvya, shows an alarming situation with a high number of newborn deaths within the first 24 hours. Group III, consisting of DS Kiremba, DS Ngozi, DS Kinyinya, DS Gitega, DS Buhiga, DS Kirundo, DS Mpanda, and DS Makamba, is characterized by frequent complications arising from untreated pregnancies. Lastly, Group IV, which contrasts with Group III along axis F1, includes DS Fota, DS Bujumbura Sud, DS Rwibaga, DS Ryansoro, DS Busoni, and DS Bugarama. This group performs better, with pregnancy-related complications significantly below the observed average.

Classification with the Dendrogram:

The next step in this analysis has been to create groups of health districts to highlight the ones, which come together. In order to understand what characterizes these groups suggested by the dendrogram, each health district was briefly compared to the other health districts of the group, then a graphic representation in radar, based on the 5 remarkable variables of the PCA was carried out.

Thanks to the HCPC () function on R, the health districts are divided into 3 groups (Figure). The first "Blue" group has 9 health districts, the second "Yellow" has 22

health districts, the third "Gray" has a single health district, the 4th "pink" has 7 health districts, the 5th "Light blue" has 2 health districts, the 6th "Pastel blue" has 2 health districts and finally the 7th "khaki green" has 4 health districts. This classification is based on the 7 final variables used for PCA.

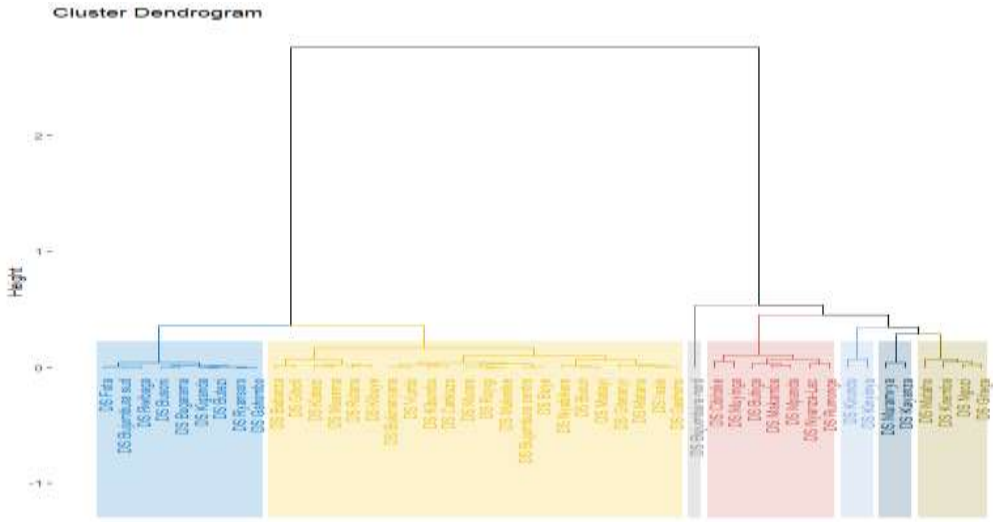

Figure 4. The classification with the Dendrogram

Partitioning with the K-means:
This visualization is on Figure 5, which is represented by different clusters with different colors.

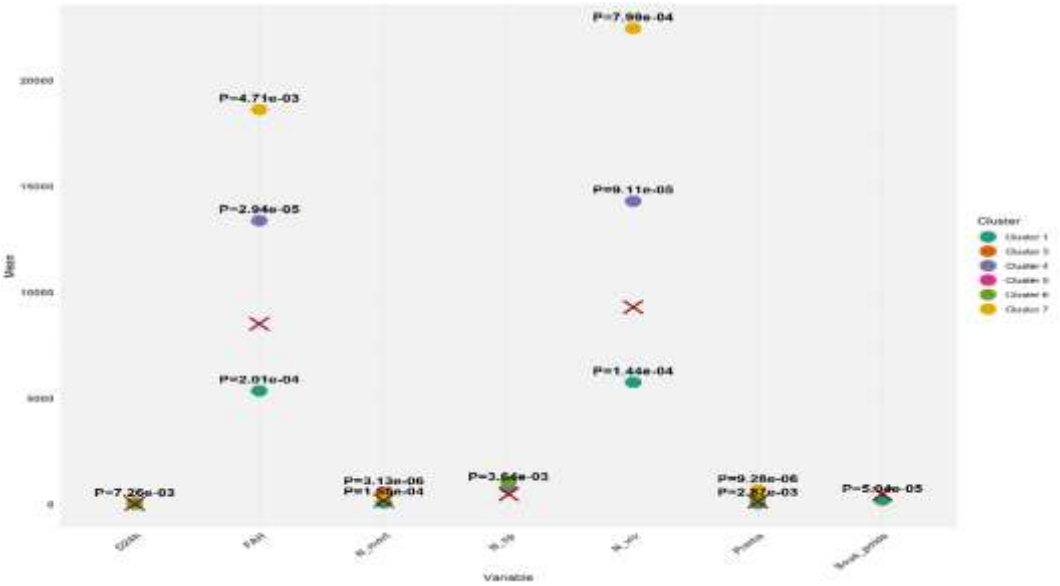

Figure 5. The Comparison of Mean in category and Overall mean

The results of this analysis reveal distinct neonatal health profiles across the different clusters. Cluster 1 (red) shows significantly lower values for premature

births, neonatal deaths within the first 24 hours, live births, and low birth weight (<2500 g), suggesting a population with lower neonatal risk. Cluster 3 (pastel blue) is defined by a higher rate of neonatal deaths within the first 24 hours, highlighting the urgent need for interventions to reduce early neonatal mortality. Cluster 4 (pink) shows higher rates of breastfeeding at delivery, live births, and low birth weight, indicating increased maternal and neonatal health concerns. Cluster 5 (light green) is characterized by a high rate of stillbirths, emphasizing the need for targeted actions to reduce stillbirth mortality. Cluster 6 (khaki green) presents higher rates of low birth weight, neonatal deaths within 24 hours, and premature births, identifying a high-risk group requiring strengthened healthcare interventions. Finally, Cluster 7 (yellow) reveals a combination of positive factors (breastfeeding) and negative ones (high rates of mortality and prematurity), suggesting a mixed health profile. These findings highlight the varying needs of different populations, ranging from low-risk groups to those requiring immediate interventions to improve maternal and neonatal health.

3 Discussion of results

Our research made the classification on various key elements determining the health situation in the health districts in Burundi. The main causes of neonatal death in Burundi were found out.

Thus, the results found that the Kayanza and Muramvya health districts have a very high number (mean=66.5) of newborn deaths compared to the other health districts (mean=22.57). The Mutaho, Kiremba, Ngozi, and Gitega health districts have a high number of stillbirths (mean=1065 vs 48 overall mean) and newborns who die within 24 hours (mean=56.25 vs 22.57 overall mean), of births before the normal term (308.75 vs 126.36 overall mean). The similar studies but identifying the major causes of neonatal death were conducted in Pakistan (Jehan et al., 2019), in Cameroon (Ndombo et al., 2017) and the Korle-Bu Teaching Hospital in Ghana (Owusu et al., 2018) have found the factors (the birth weight, place of delivery, Infectious diseases, respiratory distress, and others) to be associated with neonatal mortality. The findings of this study are likewise consistent with those of Eritrea (Andegiorgish, et al., 2020) and Sub-Saharan African studies (Ajaari, et al., 2012). Other studies (Orsido, et al., 2019) have made similar findings to the effect that birth weight is a significant risk factor of neonatal mortality. It is also in line with findings of the study (Welbeck et al., 2003) in some health districts (Kayanza and Muramvya) having a higher number of newborns dying within 24 hours due to the causes said bellow (mean=66.5 vs 22.57 overall mean). The findings of this study, which are in line with other studies(Ahmed et al., 2023) revealed that the qualified health personnel, the health of the newborn, the start of breastfeeding after birth and others are some requirements to significantly reduce neonatal mortality. The public health initiatives that aim to improve access to health care and target those at highest risk of adverse outcomes can reduce maternal and neonatal mortality; the WHO has done the same conclusion (WHO, 2012).

However, more studies did not do the data mapping for the policy makers in health

field. In this research, the results of data processing and analysis were presented in the form of tables, graphs and map. Moreover, we did not find out the difference in the infant mortality by gender. This was due to the datas, which does not provide the gender mortality gap. This study allows policy makers to make appropriate decisions to reduce neonatal in Burundi.

4 Conclusion

The Ryansoro health district, followed by the Gahombo health district, show a low number on indicators such as (newborns dying within 24 hours, births before the normal term, women breastfeeding at birth, (stillbirths with less than 2,500 grams), deliveries for live births). The Kayanza and Muramvya health districts have a higher number of newborns dying within 24 hours. The Makamba, Mpanda, Cibitoke, Muyinga, Buhiga, Nyanza-Lac and Rumonge health districts have a high number of women who breastfeed at birth, of deliveries for live births and of newborns with a weight under 2500 grams. The Kirundo and Kinyinya District hospital have a high number of (stillbirth). The Mutaho, Kiremba, Ngozi and Gitega health districts have a high number of newborns weighing less than 2,500 grams, newborns who die within 24 hours, and births before the normal term. The Bujumbura North health district has a high number of pre-term births, of deliveries for live births, of women breastfeeding at birth, of stillbirths. Further study can focus on identifying the major causes of neonatal death in Burundi and the results can be compared with conducted in Pakistan, in Cameroon and the Korle-Bu Teaching Hospital in Ghana.

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