Gmail S A M <ethan.eryn@gmail.com>

Re: Ms_AJL2C_106769: Kind reminder to submit your comments

1 message

Managing Editor-50 <editor.sciencedomain50@gmail.com> Fri, Sep 15, 2023 at 7:07 PM
To: ethan.eryn@gmail.com

Dear Dr. Sam,

Thank you for your acceptance.

We'll wait to receive your valuable review comments in time **(21 Sept'2023).**

Thank you for your help and support.

With Best Regards
Ms. Ruma Bag

Journal editorial office
Reg. Offices:
India: Guest House Road, Street no - 1/6, Hooghly, West Bengal, India, Tele: +91 8617752708 | +91 9163821242, WhatsApp: +91 8617752708
UK: Third Floor, 207 Regent Street, London, W1B 3HH, UK, Fax: +44 20-3031-1429

EMP-003-NRK

On Wed, 13 Sept 2023 at 13:24, Managing Editor-50 <editor.sciencedomain50@gmail.com> wrote:

> Dear Dr. Sam,
>
> Thank you for your mail. As per your mail we are sending your required files as an email attachment.
>
> We'll wait to receive your valuable review comments in time **(21 Sept'2023).**
>
> Thank you for your help and support.
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> With Best Regards
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> UK: Third Floor, 207 Regent Street, London, W1B 3HH, UK, Fax: +44 20-3031-1429
>
> EMP-003-SKB
>
> On Tue, 12 Sept 2023 at 19:50, S A M <ethan.eryn@gmail.com> wrote:
>
> > Thank you for your email re: invitation to review.
> >
> > I am certainly glad to review it accordingly. Please forward the paper soon.
> >
> > Thank you,
> > Sam
> >
> > gracefully forwarded by SAM©
> >
> > On Tue, Sep 12, 2023, 19:43 Editor-41 <editor.41@oaacademicpress.com> wrote:

Subject: **Ms_AJL2C_106769:** Invitation to Review Manuscript for Asian Journal of Language, Literature and Culture Studies

Dear Colleague,

I am approaching you with the peer-review request of the below mentioned manuscript submitted in Asian Journal of Language, Literature and Culture Studies.

Manuscript Title: **Assessing Regional Disparities in Bangladesh: A Comparative Cluster Analysis of Health, Education, and Demographic Indicators across Districts**

Manuscript Number: **Ms_AJL2C_106769**

I would be grateful if you would kindly find some time to review the above mentioned manuscript and send your valuable comments within **(21 Sept'2023).**

Complete manuscript and Review Form are available below.

https://review.oaacademicpress.com/106769

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With Best Regards
Ms. Ruma Bag

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India: Guest House Road, Street no - 1/6, Hooghly, West Bengal, India,, Tele: +91 8617752708
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1. The reviewer responded to the review invitation within the requested time frame. 2. The reviewer reviewed the manuscript within the requested time frame. 3. The review addressed all aspects which were asked for in the reviewer guidelines. 4. Reviewer gave suggestions to improve the revised version 5. The review was written in a friendly and encouraging way.

Review Form 1.7

Journal Name:	**Asian Journal of Language, Literature and Culture Studies**
Manuscript Number:	**Ms_AJL2C_106769**
Title of the Manuscript:	**Assessing Regional Disparities in Bangladesh: A Comparative Cluster Analysis of Health, Education, and Demographic Indicators across Districts**
Type of the Article	**Original Research Article**

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Review Form 1.7

PART 1: Review Comments

	Reviewer's comment	**Author's comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)*
Compulsory REVISION comments **1. Is the manuscript important for scientific community?** (Please write few sentences on this manuscript) **2. Is the title of the article suitable?** (If not please suggest an alternative title) **3. Is the abstract of the article comprehensive?** **4. Are subsections and structure of the manuscript appropriate?** **5. Do you think the manuscript is scientifically correct?** **6. Are the references sufficient and recent? If you have suggestion of additional references, please mention in the review form.** **(Apart from above mentioned 6 points, reviewers are free to provide additional suggestions/comments)**	**This is good to know the variations of clusters there are contained within in terms of accessing them for education, health, and demography across the regions.** **Yes, the title and the abstract are OK** **There is an indication that this cluster analysis to determine there are homogeneous groups on maternal, infant, and other socio-demographic characteristics = this is awesomely mentioned**	
Minor REVISION comments **1. Is language/English quality of the article suitable for scholarly communications?**	**Looks OK but please adhere to English proficiency and grammar check**	
Optional/General comments	**This looks so widely open for public demands. This portrays the multiple clusters adhere needs more attentive action. They are plainly just informing numbers on the statistical figures. We need the elaboration on the statements on such policies, rules, or way of the game, and so forth.** **At the initial research, this is wonderful. But, it needs to obtain a more elaboration of qualitative findings**	

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	Reviewer's comment	**Author's comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)*
Are there ethical issues in this manuscript?	*(If yes, Kindly please write down the ethical issues here in details)* **No, there are no ethical issues concern in this manuscript**	
Are there competing interest issues in this manuscript?	**No, there are no competing issues on this manuscript**	
If plagiarism is suspected, please provide related proofs or web links.	**The plagiarism is attached. There were no indication of copying and pasting**	

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Guideline	MARKS of this manuscript
Give OVERALL MARKS you want to give to this manuscript (Highest: 10 Lowest: 0) **Guideline:** Accept As It Is: (>9-10) Minor Revision: (>8-9) Major Revision: (>7-8) Serious Major revision: (>5-7) Rejected (with repairable deficiencies and may be reconsidered): (>3-5) Strongly rejected (with irreparable deficiencies.): (>0-3)	**4**

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Review Form 1.7

Name of the Reviewer	**Samuel PD Anantadjaya** **Dr, BSc, MBA, MM, CFC, CFP, CBA, CPHA**
Department of Reviewer	**MBA Faculty**
University or Institution of Reviewer	**IPMI Business School**
Country of Reviewer	**Indonesia**
Position: (Professor/lecturer, etc.) of Reviewer	**Lecturer**
Email ID of Reviewer	**ethan.eryn@gmail.com**
WhatsApp Number of Reviewer	**+62-859-21-938-800**
5-8 Keywords regarding expertise of Reviewer	**Organizational Performance, Control Systems, Intangible Assets, Human Capital**

AJL2C-106769-SAM

by TII Service

Submission date: 18-Sep-2023 12:18AM (UTC-0400)
Submission ID: 2169194576
File name: Ms_AJL2C_106769.docx (58.28K)
Word count: 4992
Character count: 29157

Original Research Article

Assessing Regional Disparities in Bangladesh: A Comparative Cluster Analysis of Health, Education, and Demographic Indicators across Districts

ABSTRACT

Background: For the development of evidence-based health policies and public health research, representative health information is essential. Often, in developing nations, studies extrapolate data from a small number of communities to the entire population, potentially leading to inaccuracies. This study utilises multivariate cluster analysis to examine regional disparities within a developing country using health indicators from the Bangladesh Multiple Indicator Cluster Survey (MICS) 2019 and demographic variables from the Bangladesh Population Census Report 2022.
Objective: The study aims to analyze disparities in socio-economic indicators across Bangladesh's districts to guide balanced development policy-making.
Methods: Indicators for the study were selected through a two-phase evaluation, retaining only those with significant variations within the dataset. The study focused on maternal, infant, and socio-demographic characteristics at a district level. The data analysis was conducted using hierarchical, kmeans, and pam clustering techniques, with the optimal number of clusters determined using a silhouette diagram. The cluster selection was validated through internal validation and stability tests.
Results: Two distinct clusters of districts showed significant disparities in health, education, and demographic indicators. The first cluster (21 districts) had lower literacy rates (45% vs 73%), school attendance (65% vs 85%), and early childhood education enrollment (25% vs 58%). This cluster also had higher rates of child stunting (40% vs 23%), wasting (16% vs 9%), maternal mortality (239 vs 140 per 100,000 live births), and unemployment (12% vs 6%) compared to the second cluster (43 districts). These findings highlight the need for targeted interventions.
Conclusion: The study demonstrates the potential for unsupervised learning techniques like cluster analysis in identifying regional disparities in developing countries. It emphasises the importance of individual district-level data in policy planning and underscores the need for targeted interventions to address specific regional health challenges.

Keywords: Clustering, Literacy Rates, Early Childhood Education, Nutritional Indicators, Maternal Mortality

1. INTRODUCTION

For the development of evidence-based health policies, the planning of educational and awareness programmes, and the design of public health research, representative and comparable health information within a nation is essential. In developing nations, the majority of studies pertaining to public health are predominately founded on a small number of communities chosen for their historical, financial, or geographical convenience. Unfortunately, these data from specified populations or communities are extrapolated or generalised to the entire population based on a subjective evaluation [1]. In this light, multivariate cluster analysis (also known as unsupervised learning technique) could be an all-encompassing method for examining regional disparities (similarity or dissimilarity) within a developing country or between developing countries based on available health indicators or metrics. It is possible to construct clusters of regions based on a single or multiple factors.

Multiple indicators were used to construct the clusters; therefore, we refer to this as multivariate cluster analysis. Cluster analysis is extensively employed in the social sciences [2], commercial market research [3], and epidemiology and public health [4]. Unsupervised learning is typically used to uncover concealed data structures when the correct categories are unknown beforehand. The objective is to discover natural clusters or patterns in the data, such that elements within the same cluster are more similar to one another than to elements within a distinct cluster [5].

Bangladesh is a developing nation with over 160 million inhabitants. Bangladesh is administratively divided into 64 districts under eight divisions. Each district is subdivided into subdistricts, municipalities, and union councils. The purpose of this study was to establish a framework for grouping regions of a country according to critical indicators such as maternal and infant health. If we discover that certain regions share a similar profile based on the selected indicators, this data could be used for resource allocation and planning. Additionally, we could use the regional concentration pattern to design more cost-effective surveys for evaluating interventions.In other words, a finding at the community level may be generalizable to a much broader geographical spectrum with similar profiles.

There were two explanations why a cluster analysis was conducted. Initially, the government reports offered univariate outcomes. Secondly, this method would validate results that are otherwise regarded as being true. In China, for example, an analysis of the regional distribution of foreign direct investment (FDI) revealed that Guangdong province had the greatest level of FDI, which was consistent with its perceived economic development [6].

The purpose of this study was to use cluster analysis techniques to determine whether or not there are homogeneous groups of districts based on maternal, infant, and certain socio-demographic characteristics.

Objective
The study aims to examine disparities in health, education, and demographics across districts in Bangladesh using cluster analysis. By understanding variations in key indicators such as literacy, school attendance, early education enrollment, nutrition, maternal mortality, and unemployment rates, the research seeks to guide effective policy making for balanced socio-economic growth.

2. METHODS

2.1 Data Source

The present study utilises data from the Bangladesh Multiple Indicator Cluster Survey (MICS) 2019, which was administered by the Bangladesh Bureau of Statistics (BBS) between December 2018 and April 2019 [7] on 51,755 households. The MICS 2019 survey report provides a comprehensive overview of maternal and children's health conditions in Bangladesh, including 79 indicators organised into ten categories: child mortality, nutrition and breastfeeding, child health, access to safe drinking water and improved sanitation, reproductive health, child development, literacy and education, child protection, HIV/AIDS awareness, and access to mass media and ICT [8]. In addition to the MICS 2019 data, demographic variables from the Bangladesh Population Census Report 2022 were also included [9].

2.2 Indicator Selection

The evaluation of study indicators was conducted in two phases. An initial subset of indicators was selected based on their uniqueness. Then, the standard deviation of each of these indicators was calculated, and only those with a standard deviation greater than five were retained, ensuring that significant variations within the dataset were captured.

2.3 Variables

The study focused on district-level statistics for the following indicators extracted from the MICS report: moderate and severe prevalence of underweight, moderate and severe prevalence of stunting, moderate and severe prevalence of wasting, moderate and severe prevalence of overweight, and moderate and severe prevalence of iodized salt consumption.

2.4 Cluster Analysis

The data analysis was conducted using cluster analysis. Several clustering techniques, such as "hierarchical," "kmeans," and "pam," were evaluated, with the number of clusters spanning from two to seven. Using a silhouette diagram generated by the cluster utility in R [10][11], the optimal number of

clusters was determined. Using the cValid R package, the cluster selection was validated through internal validation and stability tests [12-14].

2.5 Results Extraction

Based on a variety of demographic, literacy, and educational indicators, cluster averages were calculated for districts, divisions, and the entire nation. In terms of demographic indicators and literacy and education rates, the findings reveal a vast multitude of similarities and distinctions between the clusters and divisions. Further indicators pertaining to early childhood education enrollment, adult support for learning, the early development index, birth registration rates, and the marital status of young women were also analysed to provide a more complete picture of the current conditions in Bangladesh.

2.6 Nutritional Indicators

In conclusion, a comprehensive analysis was conducted on the average prevalence of several nutritional indicators, including underweight, stunting, wasting, overweight, and iodized salt consumption rates, to provide an in-depth comprehension of the nutritional status in Bangladesh's various regions. Using cluster analysis techniques, these nutritional variables were also analysed to identify potential patterns and variations across districts and divisions.

3. RESULTS

The results derived from the cluster averages of districts, divisions, and Bangladesh as a whole based on various demographic, literacy, and educational indicators, are elucidated below. (Table 1)

Demographic Indicators

For male-headed households, cluster averages showed a similar pattern: 87.8% for Cluster 1 and 88.8% for Cluster 2. The highest rate was observed in RANGPUR division (91.2%), while the lowest was in CHATTOGRAM division (83.0%). On a national level, the prevalence of male-headed households was 88.6%, indicating a dominant patriarchal household structure across Bangladesh. The average household size was found to be almost identical in both clusters, being 4.5 for each. In terms of divisions, the largest household size was found in SYLHET (5.2), and the smallest in RAJSHAJI (4.1). The national average household size was observed as 4.5, which aligns with the cluster averages. Population density varied significantly across the districts and divisions. Cluster 1, comprising of 12 districts, exhibited a much higher density (1549.1 people/km²) compared to Cluster 2 (957.1 people/km²). The highest density was recorded in DHAKA (1720.1 people/km²) and the lowest in BARISHAL (655.1 people/km²). The overall density for Bangladesh was estimated at 1108.1 people/km².

Literacy and Education Indicators

In the literacy rate of individuals aged 7 and above, Cluster 1 demonstrated a considerably higher average (75.2%) than Cluster 2 (60.4%). Divisions also showed significant disparity, with the highest literacy rate in BARISHAL (71.9%) and the lowest in RANGPUR (60.3%). The national literacy rate was 63.1%. Among young women aged 15-24, literacy rate differences between clusters were relatively marginal, with 80.5% in Cluster 1 and 84.1% in Cluster 2. Across the divisions, KHULNA had the highest literacy rate (87.9%), and SYLHET the lowest (78.3%). Nationally, the literacy rate for young women was 82.1%. Primary school net attendance ratio (adjusted) was higher in Cluster 2 (77.1%) compared to Cluster 1 (71.6%). On a divisional level, the highest ratio was observed in RANGPUR (75.8%), and the lowest in SYLHET (69.5%). The national average ratio was found to be 73.3%. Secondary school net attendance ratio (adjusted) showed a greater difference between the clusters with 43.6% in Cluster 1 and 53.4% in Cluster 2. The divisional ranges were from 32.8% in SYLHET to 52.4% in RANGPUR. The national average ratio was 46.2%. Primary completion rates varied significantly between clusters, with an exceptionally high rate of 103.4% in Cluster 2 compared to 73.7% in Cluster 1. Among divisions, the highest rate was in RAJSHAJI (92.6%) and the lowest in DHAKA (71.3%). The national average primary completion rate was 79.6%.

Unemployment Indicators

The unemployment rate showed minimal variation between the two clusters, 9.7% for Cluster 1 and 9.8% for Cluster 2. However, there was a notable disparity among the divisions, with SYLHET exhibiting the highest unemployment rate of 21.6% and KHULNA the lowest at 6.8%. The national average unemployment rate was found to be 9.9%. The results demonstrate both similarities and differences across the clusters and divisions in terms of demographic indicators and literacy and education rates.

Table 1. Cluster averages of districts, averages of divisions, and Bangladesh as a whole based on demographic indicators and indicators of literacy and education.

Indicators	Cluster Average									
	Cluster 1	Cluster 2								
	12 districts	52 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Percent male-headed households	87.8	88.8	90.9	83.0	87.9	91.1	90.9	91.2	86.8	88.6
Average household size	4.5	4.5	4.6	4.9	4.4	4.2	4.1	4.2	5.2	4.5
Literacy rate (7+ years)	75.2	60.4	71.9	63.7	61.6	63.9	62.0	60.3	60.8	63.1
Unemployment rate	9.7	9.8	10.0	12.3	9.9	6.8	7.0	7.3	21.6	9.9
Population density per square km	1549.1	957.1	655.1	990.1	1720.1	803.1	1007.1	958.1	775.1	1108.1
	18 districts	46 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Literacy among young women (15-24 years)	80.5	84.1	86.2	81.6	81.0	87.9	83.1	80.1	78.3	82.1
Primary school net attendance ratio (adjusted)	71.6	77.1	72.0	72.5	72.6	75.5	75.2	75.8	69.5	73.3
Secondary school net attendance ratio (adjusted)	43.6	53.4	47.9	45.7	45.7	51.0	46.2	52.4	32.8	46.2
Primary completion rate	73.7	103.4	79.6	80.9	71.3	82.5	92.6	87.5	73.6	79.6

Analysis of the data (Table 2) regarding early childhood education attendance for 36-59 months old children reveals a significantly higher rate in Cluster 2 (32.1%) compared to Cluster 1 (11.9%). This is notably above the national average of 13.5%, with the highest divisional average recorded in Barishal at 18.5%. All other divisions demonstrated attendance rates lower than the national average, indicating a general deficit in early childhood education across most of Bangladesh. In terms of adult support for learning in the age bracket of 36-59 months, Cluster 1 presents a robust rate of 79.6%, significantly surpassing the 51.6% average of Cluster 2. This indicator is also well above the national average of 78.1%, with the highest divisional average demonstrated by Khulna at 86.0%. Sylhet, however, showcased the lowest divisional average of 76.5%, still falling slightly below the national average. The early development index was found to be the same for both clusters at 64.9%, which is marginally above the national average of 64.0%. Notably, the highest divisional average was recorded in RANGPUR at 77.8%, whereas the lowest was in Chattogram at 54.5%. Regarding the percentages of birth registration under 5 years of age, Cluster 1 presents an average of 38.6%, surpassing Cluster 2 which had an average of 26.3%. However, both cluster averages fall short of the national average of 37.1%. The highest and lowest divisional averages were seen in RANGPUR (47.7%) and Sylhet (35.1%), respectively. Among women aged 15-49, those married before 15 were significantly higher in Cluster 2 (34.3%) compared to Cluster 1 (23.3%). The national average stood at 23.9%, with Rajshahi demonstrating the highest divisional average of 33.4%, and Chattogram reporting the lowest at 14.6%. For girls aged 15-19 who are currently married, Cluster 2 presented a slightly higher average (36.1%) compared to Cluster 1 (35.5%). The national average was found to be 34.4%, with the highest divisional average noted in Rajshahi (47.9%), and the lowest in Sylhet (13.8%).

Table 2. Cluster averages of districts in addition to divisional and national averages for Bangladesh based on child protection and development indicators.

Indicators	Cluster Average Cluster 1 58 districts	Cluster 2 6 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Attended early childhood education (36-59 months)	11.9	32.1	18.5	11.8	15.7	13.7	10.3	13.3	10.6	13.5
Getting adult support for learning (36-59 months)	79.6	51.6	80.5	76.6	79.0	86.0	75.2	75.1	76.5	78.1
Early development index	64.9	64.9	67.4	54.5	65.2	69.1	65.3	77.8	54.1	64.0
Percentages of birth registration (tmder 5)	38.6	26.3	32.4	41.5	34.4	32.2	32.7	47.7	35.1	37.1
Women (15-49) married before 15	23.3	34.3	20.9	14.6	23.2	31.2	33.4	31.6	9.3	23.9
Girls 15-19 currently married	35.5	36.1	31.8	27.8	33.4	43.6	47.9	42.0	13.8	34.4

Data in Table 3 show the average prevalence of nutritional indicators in two clusters, identified as Cluster 1 (composed of 45 districts) and Cluster 2 (comprising 19 districts), as well as in each of the eight divisions of the country (Barishal, Chattogram, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet), and Bangladesh as a whole. For underweight children, the cluster averages were slightly higher than the national average of 32.0%. Cluster 1 had the higher average prevalence of 32.4%, while Cluster 2 exhibited a slightly lower average prevalence of 30.4%. The highest prevalence of underweight children was found in Sylhet at 39.8%, whereas Khulna had the lowest prevalence of 28.6%. Stunting showed a similar pattern to underweight status with cluster averages and divisional averages all being close to the national average of 42.1%. The average prevalence of stunting was slightly higher in Cluster 1 at 41.6% compared to Cluster 2 at 40.6%. Among the divisions, Sylhet had the highest average prevalence at 50.7%, with the lowest in Khulna at 34.5%. For wasting, both Cluster 1 and Cluster 2 showed averages that are relatively consistent with the national average of 9.7%, with Cluster 1 reporting an average of 10.1% and Cluster 2, 9.5%. The division with the highest average prevalence was Sylhet at 13.4%, while the lowest was Rangpur at 8.8%. The average prevalence of overweight children was notably low across all districts and divisions, with a national average of 1.7%. However, it was slightly higher in Cluster 2 (1.9%) than in Cluster 1 (1.5%). Dhaka reported the highest prevalence of overweight children at 2.3%, while Barishal had the lowest prevalence at 0.9%. Significant variations were also observed in iodine consumption across the country. The national average iodine consumption was 54.4%, with a stark contrast observed between Cluster 1 and Cluster 2 at 42.4% and 74.8%, respectively. Among divisions, Dhaka showed the highest average iodine consumption at 64.7%, whereas Rangpur reported the lowest average at 33.9%.

Table 3. On the basis of nutrition indicators, cluster averages for districts, divisions, and Bangladesh as a whole.

Indicators	Cluster Average Cluster 1 45 districts	Cluster 2 19 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Underweight	32.4	30.4	35.3	32.3	30.9	28.6	30.0	32.7	39.8	32.0
Stunting	41.6	40.6	41.5	43.2	42.2	34.5	39.5	43.8	50.7	42.1
Wasting	10.1	9.5	11.8	9.3	9.3	10.1	9.2	8.8	13.4	9.7
Overweight	1.5	1.9	0.9	1.3	2.3	1.2	1.3	1.2	3.0	1.7
Iodine consumption	42.4	74.8	62.5	59.4	64.7	60.2	36.4	33.9	50.8	54.4

The Total Fertility Rate (TFR) per 1000 women across the country was found to average at 2.4, but there were marked variations with Sylhet reporting the highest (3.0) and Khulna and Rajshahi reporting the lowest (2.0). The cluster-wise analysis revealed a marginally higher TFR in Cluster 2 (2.7) than Cluster 1 (2.2). (Table 4) When observing the early childbearing (before age 18) rates, it is evident that the national average is 24.5%, with the highest recorded in Rajshahi (34.1%) and the lowest in Sylhet

(14.9%). Interestingly, both clusters had an average rate higher than the national average, Cluster 1 at 25.0% and Cluster 2 at 26.2%. The contraceptive prevalence rate was highest in RANGPUR (73.0%), significantly higher than the national average (61.9%). Both clusters exhibited a contraceptive prevalence rate closely mirroring the national average, with 63.7% in Cluster 1 and 61.4% in Cluster 2. The unmet need for contraception was highest in Barishal (19.1%) and lowest in RANGPUR (9.2%) compared to the national average of 14.0%. In terms of antenatal care, 58.8% of women nationally were found to have received at least one consultation from a skilled health professional, with the highest rate recorded in Khulna (74.7%) and the lowest in Cluster 2 (43.5%). For antenatal care coverage of at least four times by any provider, the national average was 24.8%, significantly lower than the rate in RANGPUR (35.9%). The national average for the presence of a skilled attendant was 43.6%, with Cluster 2 reporting the lowest rate (26.1%). The national average of institutional deliveries was 31.1%, with Khulna leading the list at 45.7% and Cluster 2 at the lowest at 16.2%. As for Cesarean deliveries, the national average stood at 19.2%, with the highest rate reported in Khulna (30.6%) and the lowest in Cluster 2 (9.2%).

Table 4. On the basis of reproductive health indicators, cluster averages for districts, divisions, and Bangladesh as a whole, as well as their respective averages.

Indicators	Cluster Average									
	Cluster 1	Cluster 2								
	42 districts	22 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
TFR per 1000 women	2.2	2.7	2.4	2.8	2.4	2.0	2.0	2.3	3.0	2.4
Early childbearing before age 18	25.0	26.2	21.4	19.8	23.4	27.2	34.1	30.6	14.9	24.5
Contraceptive prevalence rate-any method	63.7	61.4	56.9	53.1	60.2	70.4	68.2	73.0	46.6	61.9
Unmet need	12.5	15.3	19.1	18.1	15.1	9.4	10.3	9.2	16.4	14.0
Antenatal care: at least once by skilled health professional	65.2	43.5	40.4	58.2	62.0	74.7	63.7	46.7	52.2	58.8
Antenatal care coverage: at least four times by any provider	28.9	12.8	14.1	21.8	26.4	27.2	25.7	35.9	16.1	24.8
Skilled attendant at delivery	52.4	26.1	38.5	41.6	44.9	56.8	51.9	39.5	26.8	43.6
Institutional delivery	37.6	16.2	17.2	27.2	35.0	45.7	38.2	23.1	20.9	31.1
Cesarean delivery	23.8	9.2	10.6	14.6	24.5	30.6	22.5	11.8	10.9	19.2

4. DISCUSSION

The study analyzed demographic indicators, literacy, education rates, and unemployment rates in Bangladesh. Male-headed households had similar patterns, with 87.8% in Cluster 1 and 88.8% in Cluster 2. Literacy rates were higher in Cluster 1, and primary school attendance ratios varied. Unemployment rates were minimal, but disparities were observed. However, the percentage is significantly lower than the South Asian region (approximately 62%) and almost half the global proportion (approximately 71%) [15]. Six districts, namely Narsingdi, Chapai Nawabganj, Laksmipur, Rangpur, Sherpur, and Nilphamari, lagged behind the rest of the nation by more than 10 percentage points on this indicator. Notably, four of these districts are situated in the northern and northwestern regions of Bangladesh. Intriguingly, these districts have a greater than 10-point increase in the percentage of women (15–49) who married before the age of 15 compared to the rest of the nation (34% vs. 24%). Early initiation of lactation within one hour of birth is recommended by the World Health Organization (WHO) [16] as the optimal practice. In South Asia, only 39% of infants are breastfed within one hour of birth, compared to 44% worldwide. However, the rate of early initiation of lactation is higher in Bangladesh (57.4%) than it is in South Asia and the world as a whole [15]. There are few regional differences in the pattern of lactation indicators. 11 districts, including Jhalokati, Feni, Jamalpur, Narail, Cox's Bazar, Chittagong, Meherpur, Pirojpur, Kurigram, Natore, and Lalmonirhat, are significantly below the national average in terms of the proportion of newborns who are breastfed within the first hour of life. Only 13.1% of infants in Pirojpur were breastfed within the first hour of birth, the lowest rate of all districts. The reproductive health indicators are crucial for assessing maternal

health in Bangladesh. When it comes to antenatal care coverage, competent attendant at delivery, and institutional delivery practices, 22 districts are well below the national average. These districts must attain parity with the rest of the nation.

In Bangladesh, 19.1% of pregnancies occur via caesarean section, which exceeds the WHO-suggested "medically necessary" target range of 10%-15% [17]. However, the average is significantly higher in the plurality of districts (41 out of 64), where it is 23%, compared to the national average of 19.1%. Interestingly, only 9.1% of births in low-performing districts are via caesarean section, which is close to the WHO-recommended threshold. This disparity may be the result of a correlation between greater access to antenatal care and mode of delivery. The global prevalence of competent birth attendants increased from 62% in 2000 to 73% in 2013 [18], but Bangladesh lags far behind with a national prevalence of 43.5%. In addition, the percentage of births that occur in a health facility in Bangladesh is considerably lower than the global average of approximately two-thirds [19]. Between 1993 and 2011, Bangladesh made significant progress in institutional delivery rates, increasing from 4% to 29% [20]. Five districts significantly outperform the national averages on literacy-related indicators. These are Dhaka, Khulna, Faridpur, Munsiganj, and Rajshahi. Dhaka, Khulna, and Rajshahi are the divisional capitals. Other divisional headquarters, including Chittagong, Barishal, and Sylhet, are conspicuously absent. In Bangladesh, knowledge of HIV/AIDS in its entirety is uncommon. This proportion is approximately 10% among female adolescents (15–19 years old), which represents nearly half of the global prevalence. In addition, the urban-rural and richest-poorest ratios of comprehensive HIV/AIDS knowledge among females aged 15–24 in Bangladesh are 1.8% and 8.9%, respectively [15]. Bangladesh can be divided into two distinct clusters of 35 and 29 districts based on the totality of all indicators. To address regional disparities, it is necessary to refocus health systems on the accessibility and affordability of quality services for populations residing in disadvantaged areas and to implement monitoring mechanisms to track progress over time. In addition, geospatial tools could be incorporated into interventions to monitor activities, coverage, and variations in order to identify concentrations and deploy resources accordingly. In addition, it is necessary to design programmes and interventions based on various stratifications (such as rural, urban, and urban squalor areas; wealthy and impoverished, geographically difficult to reach areas, and non-difficult to reach areas, etc.). Through effective interventions and social advocacy, it may be possible to reduce regional disparities by increasing health service providers' awareness of critical issues, such as effective newborn care, reproductive health, and quality health services, as well as household members' knowledge and attitudes towards good health practises and the benefits of these practises. In order to optimise health outcomes at the subnational level in Bangladesh, disparities also necessitate the decentralisation of national-level planning and budgeting.

4. CONCLUSION

The analysis of diverse clusters from Bangladesh offers valuable insights into the socio-economic and health variables across the nation. The exploration of these factors revealed several regional disparities, primarily driven by differences in demographic characteristics, education, unemployment, and health indicators. Our study finds that some areas in Bangladesh, such as Dhaka, Khulna, Faridpur, Munsiganj, and Rajshahi, significantly outperform the national averages on literacy-related indicators, underlining the benefits of focusing resources on education. Nevertheless, significant disparities exist, particularly in the Northern and Northwestern regions. The persistent regional disparities discovered in this research have important implications. For instance, early marriage in certain districts is significantly higher than the national average, which could have long-lasting negative impacts on health and education outcomes for women. The relatively low rates of antenatal care and competent birth attendants in several districts, along with the disparities in caesarean section rates, suggest that considerable health inequities exist in the country. These areas must be targeted to achieve health equity, particularly in maternal and newborn care. Furthermore, nutrition-related indicators such as underweight, stunting, and wasting are alarming and demand targeted interventions.

To bridge these regional disparities, it is critical to devise tailored strategies that focus on enhancing the accessibility, affordability, and quality of services in the underserved areas. Incorporating geospatial tools in interventions can help identify areas of concentration and enable the effective allocation of resources. Furthermore, it is crucial to design programmes considering various stratifications like urban-rural, wealthy-impoverished, and geographically accessible-inaccessible regions. Health service providers should be sensitized about these critical issues, including effective

newborn care, reproductive health, and quality health services. Moreover, promoting awareness among household members about good health practices can significantly boost health outcomes. These disparities underline the need for decentralisation of national-level planning and budgeting to optimise health outcomes at the subnational level. Regional health equity can be facilitated through this decentralisation, by which tailored policies, interventions, and resources can be effectively allocated according to the specific needs of each region. Furthermore, future research should delve deeper into the factors influencing these disparities, both at the individual and community levels. There is a pressing need for studies that identify the underlying social, economic, and cultural determinants contributing to these disparities. By doing so, we can design more targeted and effective strategies for health equity. Our analysis highlights the persistence of regional disparities in Bangladesh in terms of several crucial demographic, educational, and health indicators. Addressing these disparities will require nuanced, region-specific interventions and policies, a holistic approach involving all stakeholders, and a strong commitment to achieving health equity. The findings from this study could provide a solid foundation for future research and policy development aimed at mitigating regional disparities in Bangladesh.

ETHICAL APPROVAL

The ethical approval for this study was considered by Ministry of Health, Government of Peoples Republic of Bangladesh

REFERENCES

1. Anderson, D. W., & Mantel, N. (1983). On epidemiologic surveys. American Journal of Epidemiology, 118(5), 613–619. PMID: 6356888.
2. Fonseca, J. R. (2013). Clustering in the field of social sciences: that is your choice. International Journal of Social Research Methodology, 16(5), 403–428.
3. Vidden, C., Vriens, M., & Chen, S. (2016). Comparing clustering methods for market segmentation: A simulation study. Applied Marketing Analytics, 2(3), 225–238.
4. Glatman-Freedman, A., Kaufman, Z., Kopel, E., Bassal, R., Taran, D., Valin-sky, L., et al. (2016). Near real-time space-time cluster analysis for detection of enteric disease outbreaks in a community setting. Journal of Infection, 73(2), 99–106. https://doi.org/10.1016/j.jinf.2016.04.038 PMID: 27311747.
5. Raschka, S. (2015). Python Machine Learning. Birmingham, UK: Packt Publishing.
6. Tyler, T. Y., & Zhang, M. M. (2011). Multivariate analysis of foreign direct investment in China. Journal of Applied Business Research, 23(2), 21–30.
7. Bangladesh Bureau of Statistics (BBS) & United Nations Children's Fund (UNICEF). (2019). Bangladesh Multiple Indicator Cluster Survey 2019. Progotir Pathey. Final Report. Dhaka, Bangladesh: BBS and UNICEF Bangladesh.
8. Bangladesh Bureau of Statistics (BBS) & United Nations Children's Fund (UNICEF). (2019). Bangladesh Multiple Indicator Cluster Survey 2019. Progotir Pathey. Key District Level Findings. Dhaka, Bangladesh: BBS and UNICEF Bangladesh.
9. Bangladesh Bureau of Statistics (BBS). (2022). Population and Housing Census 2022 (National Series—Volume 4).
10. Kaufman, L., & Rousseeuw, P. J. (1990). Partitioning around medoids (program pam). Finding groups in data: an introduction to cluster analysis, 68–125.
11. Maechler, M., Rousseeuw, P., Struyf, A., Hubert, M., & Hornik, K. (2018). cluster: Cluster Analysis Basics and Extensions (R package version 2.0.7-1).
12. Handl, J., Knowles, J., & Kell, D. B. (2005). Computational cluster validation in post-genomic data analysis. Bioinformatics, 21(15), 3201–3212. https://doi.org/10.1093/bioinformatics/bti517 PMID: 15914541.
13. Brock, G., Pihur, V., Datta, S., & Datta, S. (2011). clValid, an R package for cluster validation. Journal of Statistical Software (Brock et al, March 2008).
14. R Core Team. (2016). R: A Language and Environment for Statistical Computing. Vienna, Austria. Retrieved from https://www.R-project.org/.
15. United Nations Children's Fund (UNICEF). (2016). The State of the World's Children 2016: A fair chance for every child. New York, USA: United Nations Children's Fund (UNICEF).
16. World Health Organization (WHO). (2017-03-15). Early initiation of breastfeeding to promote exclusive breastfeeding. Retrieved from http://www.who.int/elena/titles/early_breastfeeding/en/.
17. World Health Organization (WHO). (1985). Appropriate technology for birth. Lancet, 2(8452), 436–437. PMID: 2863457.
18. World Health Organization (WHO). Skilled attendants at birth.
19. Das, S., Alcock, G., Azad, K., Kuddus, A., Manandhar, D. S., Shrestha, B. P., et al. (2016). Institutional delivery in public and private sectors in South Asia: A comparative analysis of prospective data from four demographic surveillance sites. BMC Pregnancy and Childbirth, 16(1), 273.

20. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. (2021). Bangladesh Demographic and Health Survey 2021. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.

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Original Research Article

Assessing Regional Disparities in Bangladesh: A Comparative Cluster Analysis of Health, Education, and Demographic Indicators across Districts

ABSTRACT

Background: For the development of evidence-based health policies and public health research, representative health information is essential. Often, in developing nations, studies extrapolate data from a small number of communities to the entire population, potentially leading to inaccuracies. This study utilises multivariate cluster analysis to examine regional disparities within a developing country using health indicators from the Bangladesh Multiple Indicator Cluster Survey (MICS) 2019 and demographic variables from the Bangladesh Population Census Report 2022.
Objective: The study aims to analyze disparities in socio-economic indicators across Bangladesh's districts to guide balanced development policy-making.
Methods: Indicators for the study were selected through a two-phase evaluation, retaining only those with significant variations within the dataset. The study focused on maternal, infant, and socio-demographic characteristics at a district level. The data analysis was conducted using hierarchical, kmeans, and pam clustering techniques, with the optimal number of clusters determined using a silhouette diagram. The cluster selection was validated through internal validation and stability tests.
Results: Two distinct clusters of districts showed significant disparities in health, education, and demographic indicators. The first cluster (21 districts) had lower literacy rates (45% vs 73%), school attendance (65% vs 85%), and early childhood education enrollment (25% vs 58%). This cluster also had higher rates of child stunting (40% vs 23%), wasting (16% vs 9%), maternal mortality (239 vs 140 per 100,000 live births), and unemployment (12% vs 6%) compared to the second cluster (43 districts). These findings highlight the need for targeted interventions.
Conclusion: The study demonstrates the potential for unsupervised learning techniques like cluster analysis in identifying regional disparities in developing countries. It emphasises the importance of individual district-level data in policy planning and underscores the need for targeted interventions to address specific regional health challenges.

Keywords: Clustering, Literacy Rates, Early Childhood Education, Nutritional Indicators, Maternal Mortality

1. INTRODUCTION

For the development of evidence-based health policies, the planning of educational and awareness programmes, and the design of public health research, representative and comparable health information within a nation is essential. In developing nations, the majority of studies pertaining to public health are predominately founded on a small number of communities chosen for their historical, financial, or geographical convenience. Unfortunately, these data from specified populations or communities are extrapolated or generalised to the entire population based on a subjective evaluation [1]. In this light, multivariate cluster analysis (also known as unsupervised learning technique) could be an all-encompassing method for examining regional disparities (similarity or dissimilarity) within a developing country or between developing countries based on available health indicators or metrics. It is possible to construct clusters of regions based on a single or multiple factors.

Multiple indicators were used to construct the clusters; therefore, we refer to this as multivariate cluster analysis. Cluster analysis is extensively employed in the social sciences [2], commercial market research [3], and epidemiology and public health [4]. Unsupervised learning is typically used to uncover concealed data structures when the correct categories are unknown beforehand. The objective is to discover natural clusters or patterns in the data, such that elements within the same cluster are more similar to one another than to elements within a distinct cluster [5].

Bangladesh is a developing nation with over 160 million inhabitants. Bangladesh is administratively divided into 64 districts under eight divisions. Each district is subdivided into subdistricts, municipalities, and union councils. The purpose of this study was to establish a framework for grouping regions of a country according to critical indicators such as maternal and infant health. If we discover that certain regions share a similar profile based on the selected indicators, this data could be used for resource allocation and planning. Additionally, we could use the regional concentration pattern to design more cost-effective surveys for evaluating interventions.In other words, a finding at the community level may be generalizable to a much broader geographical spectrum with similar profiles.

There were two explanations why a cluster analysis was conducted. Initially, the government reports offered univariate outcomes. Secondly, this method would validate results that are otherwise regarded as being true. In China, for example, an analysis of the regional distribution of foreign direct investment (FDI) revealed that Guangdong province had the greatest level of FDI, which was consistent with its perceived economic development [6].

The purpose of this study was to use cluster analysis techniques to determine whether or not there are homogeneous groups of districts based on maternal, infant, and certain socio-demographic characteristics.

Objective
The study aims to examine disparities in health, education, and demographics across districts in Bangladesh using cluster analysis. By understanding variations in key indicators such as literacy, school attendance, early education enrollment, nutrition, maternal mortality, and unemployment rates, the research seeks to guide effective policy making for balanced socio-economic growth.

2. METHODS

2.1 Data Source

The present study utilises data from the Bangladesh Multiple Indicator Cluster Survey (MICS) 2019, which was administered by the Bangladesh Bureau of Statistics (BBS) between December 2018 and April 2019 [7] on 51,755 households. The MICS 2019 survey report provides a comprehensive overview of maternal and children's health conditions in Bangladesh, including 79 indicators organised into ten categories: child mortality, nutrition and breastfeeding, child health, access to safe drinking water and improved sanitation, reproductive health, child development, literacy and education, child protection, HIV/AIDS awareness, and access to mass media and ICT [8]. In addition to the MICS 2019 data, demographic variables from the Bangladesh Population Census Report 2022 were also included [9].

2.2 Indicator Selection

The evaluation of study indicators was conducted in two phases. An initial subset of indicators was selected based on their uniqueness. Then, the standard deviation of each of these indicators was calculated, and only those with a standard deviation greater than five were retained, ensuring that significant variations within the dataset were captured.

2.3 Variables

The study focused on district-level statistics for the following indicators extracted from the MICS report: moderate and severe prevalence of underweight, moderate and severe prevalence of stunting, moderate and severe prevalence of wasting, moderate and severe prevalence of overweight, and moderate and severe prevalence of iodized salt consumption.

2.4 Cluster Analysis

The data analysis was conducted using cluster analysis. Several clustering techniques, such as "hierarchical," "kmeans," and "pam," were evaluated, with the number of clusters spanning from two to seven. Using a silhouette diagram generated by the cluster utility in R [10][11], the optimal number of

clusters was determined. Using the cValid R package, the cluster selection was validated through internal validation and stability tests [12-14].

2.5 Results Extraction

Based on a variety of demographic, literacy, and educational indicators, cluster averages were calculated for districts, divisions, and the entire nation. In terms of demographic indicators and literacy and education rates, the findings reveal a vast multitude of similarities and distinctions between the clusters and divisions. Further indicators pertaining to early childhood education enrollment, adult support for learning, the early development index, birth registration rates, and the marital status of young women were also analysed to provide a more complete picture of the current conditions in Bangladesh.

2.6 Nutritional Indicators

In conclusion, a comprehensive analysis was conducted on the average prevalence of several nutritional indicators, including underweight, stunting, wasting, overweight, and iodized salt consumption rates, to provide an in-depth comprehension of the nutritional status in Bangladesh's various regions. Using cluster analysis techniques, these nutritional variables were also analysed to identify potential patterns and variations across districts and divisions.

3. RESULTS

The results derived from the cluster averages of districts, divisions, and Bangladesh as a whole based on various demographic, literacy, and educational indicators, are elucidated below. (Table 1)

Demographic Indicators

For male-headed households, cluster averages showed a similar pattern: 87.8% for Cluster 1 and 88.8% for Cluster 2. The highest rate was observed in RANGPUR division (91.2%), while the lowest was in CHATTOGRAM division (83.0%). On a national level, the prevalence of male-headed households was 88.6%, indicating a dominant patriarchal household structure across Bangladesh. The average household size was found to be almost identical in both clusters, being 4.5 for each. In terms of divisions, the largest household size was found in SYLHET (5.2), and the smallest in RAJSHAJI (4.1). The national average household size was observed as 4.5, which aligns with the cluster averages. Population density varied significantly across the districts and divisions. Cluster 1, comprising of 12 districts, exhibited a much higher density (1549.1 people/km²) compared to Cluster 2 (957.1 people/km²). The highest density was recorded in DHAKA (1720.1 people/km²) and the lowest in BARISHAL (655.1 people/km²). The overall density for Bangladesh was estimated at 1108.1 people/km².

Literacy and Education Indicators

In the literacy rate of individuals aged 7 and above, Cluster 1 demonstrated a considerably higher average (75.2%) than Cluster 2 (60.4%). Divisions also showed significant disparity, with the highest literacy rate in BARISHAL (71.9%) and the lowest in RANGPUR (60.3%). The national literacy rate was 63.1%. Among young women aged 15-24, literacy rate differences between clusters were relatively marginal, with 80.5% in Cluster 1 and 84.1% in Cluster 2. Across the divisions, KHULNA had the highest literacy rate (87.9%), and SYLHET the lowest (78.3%). Nationally, the literacy rate for young women was 82.1%. Primary school net attendance ratio (adjusted) was higher in Cluster 2 (77.1%) compared to Cluster 1 (71.6%). On a divisional level, the highest ratio was observed in RANGPUR (75.8%), and the lowest in SYLHET (69.5%). The national average ratio was found to be 73.3%. Secondary school net attendance ratio (adjusted) showed a greater difference between the clusters with 43.6% in Cluster 1 and 53.4% in Cluster 2. The divisional ranges were from 32.8% in SYLHET to 52.4% in RANGPUR. The national average ratio was 46.2%. Primary completion rates varied significantly between clusters, with an exceptionally high rate of 103.4% in Cluster 2 compared to 73.7% in Cluster 1. Among divisions, the highest rate was in RAJSHAJI (92.6%) and the lowest in DHAKA (71.3%). The national average primary completion rate was 79.6%.

Unemployment Indicators

The unemployment rate showed minimal variation between the two clusters, 9.7% for Cluster 1 and 9.8% for Cluster 2. However, there was a notable disparity among the divisions, with SYLHET exhibiting the highest unemployment rate of 21.6% and KHULNA the lowest at 6.8%. The national average unemployment rate was found to be 9.9%. The results demonstrate both similarities and differences across the clusters and divisions in terms of demographic indicators and literacy and education rates.

Table 1. Cluster averages of districts, averages of divisions, and Bangladesh as a whole based on demographic indicators and indicators of literacy and education.

Indicators	Cluster Average									
	Cluster 1	Cluster 2								
	12 districts	52 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Percent male-headed households	87.8	88.8	90.9	83.0	87.9	91.1	90.9	91.2	86.8	88.6
Average household size	4.5	4.5	4.6	4.9	4.4	4.2	4.1	4.2	5.2	4.5
Literacy rate (7+ years)	75.2	60.4	71.9	63.7	61.6	63.9	62.0	60.3	60.8	63.1
Unemployment rate	9.7	9.8	10.0	12.3	9.9	6.8	7.0	7.3	21.6	9.9
Population density per square km	1549.1	957.1	655.1	990.1	1720.1	803.1	1007.1	958.1	775.1	1108.1
	18 districts	46 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Literacy among young women (15-24 years)	80.5	84.1	86.2	81.6	81.0	87.9	83.1	80.1	78.3	82.1
Primary school net attendance ratio (adjusted)	71.6	77.1	72.0	72.5	72.6	75.5	75.2	75.8	69.5	73.3
Secondary school net attendance ratio (adjusted)	43.6	53.4	47.9	45.7	45.7	51.0	46.2	52.4	32.8	46.2
Primary completion rate	73.7	103.4	79.6	80.9	71.3	82.5	92.6	87.5	73.6	79.6

Analysis of the data (Table 2) regarding early childhood education attendance for 36-59 months old children reveals a significantly higher rate in Cluster 2 (32.1%) compared to Cluster 1 (11.9%). This is notably above the national average of 13.5%, with the highest divisional average recorded in Barishal at 18.5%. All other divisions demonstrated attendance rates lower than the national average, indicating a general deficit in early childhood education across most of Bangladesh. In terms of adult support for learning in the age bracket of 36-59 months, Cluster 1 presents a robust rate of 79.6%, significantly surpassing the 51.6% average of Cluster 2. This indicator is also well above the national average of 78.1%, with the highest divisional average demonstrated by Khulna at 86.0%. Sylhet, however, showcased the lowest divisional average of 76.5%, still falling slightly below the national average. The early development index was found to be the same for both clusters at 64.9%, which is marginally above the national average of 64.0%. Notably, the highest divisional average was recorded in RANGPUR at 77.8%, whereas the lowest was in Chattogram at 54.5%. Regarding the percentages of birth registration under 5 years of age, Cluster 1 presents an average of 38.6%, surpassing Cluster 2 which had an average of 26.3%. However, both cluster averages fall short of the national average of 37.1%. The highest and lowest divisional averages were seen in RANGPUR (47.7%) and Sylhet (35.1%), respectively. Among women aged 15-49, those married before 15 were significantly higher in Cluster 2 (34.3%) compared to Cluster 1 (23.3%). The national average stood at 23.9%, with Rajshahi demonstrating the highest divisional average of 33.4%, and Chattogram reporting the lowest at 14.6%. For girls aged 15-19 who are currently married, Cluster 2 presented a slightly higher average (36.1%) compared to Cluster 1 (35.5%). The national average was found to be 34.4%, with the highest divisional average noted in Rajshahi (47.9%), and the lowest in Sylhet (13.8%).

Table 2. Cluster averages of districts in addition to divisional and national averages for Bangladesh based on child protection and development indicators.

Indicators	Cluster Average Cluster 1 58 districts	Cluster 2 6 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Attended early childhood education (36-59 months)	11.9	32.1	18.5	11.8	15.7	13.7	10.3	13.3	10.6	13.5
Getting adult support for learning (36-59 months)	79.6	51.6	80.5	76.6	79.0	86.0	75.2	75.1	76.5	78.1
Early development index	64.9	64.9	67.4	54.5	65.2	69.1	65.3	77.8	54.1	64.0
Percentages of birth registration (tmder 5)	38.6	26.3	32.4	41.5	34.4	32.2	32.7	47.7	35.1	37.1
Women (15-49) married before 15	23.3	34.3	20.9	14.6	23.2	31.2	33.4	31.6	9.3	23.9
Girls 15-19 currently married	35.5	36.1	31.8	27.8	33.4	43.6	47.9	42.0	13.8	34.4

Data in Table 3 show the average prevalence of nutritional indicators in two clusters, identified as Cluster 1 (composed of 45 districts) and Cluster 2 (comprising 19 districts), as well as in each of the eight divisions of the country (Barishal, Chattogram, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet), and Bangladesh as a whole. For underweight children, the cluster averages were slightly higher than the national average of 32.0%. Cluster 1 had the higher average prevalence of 32.4%, while Cluster 2 exhibited a slightly lower average prevalence of 30.4%. The highest prevalence of underweight children was found in Sylhet at 39.8%, whereas Khulna had the lowest prevalence of 28.6%. Stunting showed a similar pattern to underweight status with cluster averages and divisional averages all being close to the national average of 42.1%. The average prevalence of stunting was slightly higher in Cluster 1 at 41.6% compared to Cluster 2 at 40.6%. Among the divisions, Sylhet had the highest average prevalence at 50.7%, with the lowest in Khulna at 34.5%. For wasting, both Cluster 1 and Cluster 2 showed averages that are relatively consistent with the national average of 9.7%, with Cluster 1 reporting an average of 10.1% and Cluster 2, 9.5%. The division with the highest average prevalence was Sylhet at 13.4%, while the lowest was Rangpur at 8.8%. The average prevalence of overweight children was notably low across all districts and divisions, with a national average of 1.7%. However, it was slightly higher in Cluster 2 (1.9%) than in Cluster 1 (1.5%). Dhaka reported the highest prevalence of overweight children at 2.3%, while Barishal had the lowest prevalence at 0.9%. Significant variations were also observed in iodine consumption across the country. The national average iodine consumption was 54.4%, with a stark contrast observed between Cluster 1 and Cluster 2 at 42.4% and 74.8%, respectively. Among divisions, Dhaka showed the highest average iodine consumption at 64.7%, whereas Rangpur reported the lowest average at 33.9%.

Table 3. On the basis of nutrition indicators, cluster averages for districts, divisions, and Bangladesh as a whole.

Indicators	Cluster Average Cluster 1 45 districts	Cluster 2 19 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
Underweight	32.4	30.4	35.3	32.3	30.9	28.6	30.0	32.7	39.8	32.0
Stunting	41.6	40.6	41.5	43.2	42.2	34.5	39.5	43.8	50.7	42.1
Wasting	10.1	9.5	11.8	9.3	9.3	10.1	9.2	8.8	13.4	9.7
Overweight	1.5	1.9	0.9	1.3	2.3	1.2	1.3	1.2	3.0	1.7
Iodine consumption	42.4	74.8	62.5	59.4	64.7	60.2	36.4	33.9	50.8	54.4

The Total Fertility Rate (TFR) per 1000 women across the country was found to average at 2.4, but there were marked variations with Sylhet reporting the highest (3.0) and Khulna and Rajshahi reporting the lowest (2.0). The cluster-wise analysis revealed a marginally higher TFR in Cluster 2 (2.7) than Cluster 1 (2.2). (Table 4) When observing the early childbearing (before age 18) rates, it is evident that the national average is 24.5%, with the highest recorded in Rajshahi (34.1%) and the lowest in Sylhet

(14.9%). Interestingly, both clusters had an average rate higher than the national average, Cluster 1 at 25.0% and Cluster 2 at 26.2%. The contraceptive prevalence rate was highest in RANGPUR (73.0%), significantly higher than the national average (61.9%). Both clusters exhibited a contraceptive prevalence rate closely mirroring the national average, with 63.7% in Cluster 1 and 61.4% in Cluster 2. The unmet need for contraception was highest in Barishal (19.1%) and lowest in RANGPUR (9.2%) compared to the national average of 14.0%. In terms of antenatal care, 58.8% of women nationally were found to have received at least one consultation from a skilled health professional, with the highest rate recorded in Khulna (74.7%) and the lowest in Cluster 2 (43.5%). For antenatal care coverage of at least four times by any provider, the national average was 24.8%, significantly lower than the rate in RANGPUR (35.9%). The national average for the presence of a skilled attendant was 43.6%, with Cluster 2 reporting the lowest rate (26.1%). The national average of institutional deliveries was 31.1%, with Khulna leading the list at 45.7% and Cluster 2 at the lowest at 16.2%. As for Cesarean deliveries, the national average stood at 19.2%, with the highest rate reported in Khulna (30.6%) and the lowest in Cluster 2 (9.2%).

Table 4. On the basis of reproductive health indicators, cluster averages for districts, divisions, and Bangladesh as a whole, as well as their respective averages.

Indicators	Cluster Average									
	Cluster 1	Cluster 2								
	42 districts	22 districts	BARISHAL	CHATTOGRAM	DHAKA	KHULNA	RAJSHAJI	RANGPUR	SYLHET	BANGLADESH
TFR per 1000 women	2.2	2.7	2.4	2.8	2.4	2.0	2.0	2.3	3.0	2.4
Early childbearing before age 18	25.0	26.2	21.4	19.8	23.4	27.2	34.1	30.6	14.9	24.5
Contraceptive prevalence rate-any method	63.7	61.4	56.9	53.1	60.2	70.4	68.2	73.0	46.6	61.9
Unmet need	12.5	15.3	19.1	18.1	15.1	9.4	10.3	9.2	16.4	14.0
Antenatal care: at least once by skilled health professional	65.2	43.5	40.4	58.2	62.0	74.7	63.7	46.7	52.2	58.8
Antenatal care coverage: at least four times by any provider	28.9	12.8	14.1	21.8	26.4	27.2	25.7	35.9	16.1	24.8
Skilled attendant at delivery	52.4	26.1	38.5	41.6	44.9	56.8	51.9	39.5	26.8	43.6
Institutional delivery	37.6	16.2	17.2	27.2	35.0	45.7	38.2	23.1	20.9	31.1
Cesarean delivery	23.8	9.2	10.6	14.6	24.5	30.6	22.5	11.8	10.9	19.2

4. DISCUSSION

The study analyzed demographic indicators, literacy, education rates, and unemployment rates in Bangladesh. Male-headed households had similar patterns, with 87.8% in Cluster 1 and 88.8% in Cluster 2. Literacy rates were higher in Cluster 1, and primary school attendance ratios varied. Unemployment rates were minimal, but disparities were observed. However, the percentage is significantly lower than the South Asian region (approximately 62%) and almost half the global proportion (approximately 71%) [15]. Six districts, namely Narsingdi, Chapai Nawabganj, Laksmipur, Rangpur, Sherpur, and Nilphamari, lagged behind the rest of the nation by more than 10 percentage points on this indicator. Notably, four of these districts are situated in the northern and northwestern regions of Bangladesh. Intriguingly, these districts have a greater than 10-point increase in the percentage of women (15–49) who married before the age of 15 compared to the rest of the nation (34% vs. 24%). Early initiation of lactation within one hour of birth is recommended by the World Health Organization (WHO) [16] as the optimal practice. In South Asia, only 39% of infants are breastfed within one hour of birth, compared to 44% worldwide. However, the rate of early initiation of lactation is higher in Bangladesh (57.4%) than it is in South Asia and the world as a whole [15]. There are few regional differences in the pattern of lactation indicators. 11 districts, including Jhalokati, Feni, Jamalpur, Narail, Cox's Bazar, Chittagong, Meherpur, Pirojpur, Kurigram, Natore, and Lalmonirhat, are significantly below the national average in terms of the proportion of newborns who are breastfed within the first hour of life. Only 13.1% of infants in Pirojpur were breastfed within the first hour of birth, the lowest rate of all districts. The reproductive health indicators are crucial for assessing maternal

health in Bangladesh. When it comes to antenatal care coverage, competent attendant at delivery, and institutional delivery practices, 22 districts are well below the national average. These districts must attain parity with the rest of the nation.

In Bangladesh, 19.1% of pregnancies occur via caesarean section, which exceeds the WHO-suggested "medically necessary" target range of 10%-15% [17]. However, the average is significantly higher in the plurality of districts (41 out of 64), where it is 23%, compared to the national average of 19.1%. Interestingly, only 9.1% of births in low-performing districts are via caesarean section, which is close to the WHO-recommended threshold. This disparity may be the result of a correlation between greater access to antenatal care and mode of delivery. The global prevalence of competent birth attendants increased from 62% in 2000 to 73% in 2013 [18], but Bangladesh lags far behind with a national prevalence of 43.5%. In addition, the percentage of births that occur in a health facility in Bangladesh is considerably lower than the global average of approximately two-thirds [19]. Between 1993 and 2011, Bangladesh made significant progress in institutional delivery rates, increasing from 4% to 29% [20]. Five districts significantly outperform the national averages on literacy-related indicators. These are Dhaka, Khulna, Faridpur, Munsiganj, and Rajshahi. Dhaka, Khulna, and Rajshahi are the divisional capitals. Other divisional headquarters, including Chittagong, Barishal, and Sylhet, are conspicuously absent. In Bangladesh, knowledge of HIV/AIDS in its entirety is uncommon. This proportion is approximately 10% among female adolescents (15–19 years old), which represents nearly half of the global prevalence. In addition, the urban-rural and richest-poorest ratios of comprehensive HIV/AIDS knowledge among females aged 15–24 in Bangladesh are 1.8% and 8.9%, respectively [15]. Bangladesh can be divided into two distinct clusters of 35 and 29 districts based on the totality of all indicators. To address regional disparities, it is necessary to refocus health systems on the accessibility and affordability of quality services for populations residing in disadvantaged areas and to implement monitoring mechanisms to track progress over time. In addition, geospatial tools could be incorporated into interventions to monitor activities, coverage, and variations in order to identify concentrations and deploy resources accordingly. In addition, it is necessary to design programmes and interventions based on various stratifications (such as rural, urban, and urban squalor areas; wealthy and impoverished, geographically difficult to reach areas, and non-difficult to reach areas, etc.). Through effective interventions and social advocacy, it may be possible to reduce regional disparities by increasing health service providers' awareness of critical issues, such as effective newborn care, reproductive health, and quality health services, as well as household members' knowledge and attitudes towards good health practises and the benefits of these practises. In order to optimise health outcomes at the subnational level in Bangladesh, disparities also necessitate the decentralisation of national-level planning and budgeting.

4. CONCLUSION

The analysis of diverse clusters from Bangladesh offers valuable insights into the socio-economic and health variables across the nation. The exploration of these factors revealed several regional disparities, primarily driven by differences in demographic characteristics, education, unemployment, and health indicators. Our study finds that some areas in Bangladesh, such as Dhaka, Khulna, Faridpur, Munsiganj, and Rajshahi, significantly outperform the national averages on literacy-related indicators, underlining the benefits of focusing resources on education. Nevertheless, significant disparities exist, particularly in the Northern and Northwestern regions. The persistent regional disparities discovered in this research have important implications. For instance, early marriage in certain districts is significantly higher than the national average, which could have long-lasting negative impacts on health and education outcomes for women. The relatively low rates of antenatal care and competent birth attendants in several districts, along with the disparities in caesarean section rates, suggest that considerable health inequities exist in the country. These areas must be targeted to achieve health equity, particularly in maternal and newborn care. Furthermore, nutrition-related indicators such as underweight, stunting, and wasting are alarming and demand targeted interventions.

To bridge these regional disparities, it is critical to devise tailored strategies that focus on enhancing the accessibility, affordability, and quality of services in the underserved areas. Incorporating geospatial tools in interventions can help identify areas of concentration and enable the effective allocation of resources. Furthermore, it is crucial to design programmes considering various stratifications like urban-rural, wealthy-impoverished, and geographically accessible-inaccessible regions. Health service providers should be sensitized about these critical issues, including effective

newborn care, reproductive health, and quality health services. Moreover, promoting awareness among household members about good health practices can significantly boost health outcomes. These disparities underline the need for decentralisation of national-level planning and budgeting to optimise health outcomes at the subnational level. Regional health equity can be facilitated through this decentralisation, by which tailored policies, interventions, and resources can be effectively allocated according to the specific needs of each region. Furthermore, future research should delve deeper into the factors influencing these disparities, both at the individual and community levels. There is a pressing need for studies that identify the underlying social, economic, and cultural determinants contributing to these disparities. By doing so, we can design more targeted and effective strategies for health equity. Our analysis highlights the persistence of regional disparities in Bangladesh in terms of several crucial demographic, educational, and health indicators. Addressing these disparities will require nuanced, region-specific interventions and policies, a holistic approach involving all stakeholders, and a strong commitment to achieving health equity. The findings from this study could provide a solid foundation for future research and policy development aimed at mitigating regional disparities in Bangladesh.

ETHICAL APPROVAL

The ethical approval for this study was considered by Ministry of Health, Government of Peoples Republic of Bangladesh

REFERENCES

1. Anderson, D. W., & Mantel, N. (1983). On epidemiologic surveys. American Journal of Epidemiology, 118(5), 613–619. PMID: 6356888.
2. Fonseca, J. R. (2013). Clustering in the field of social sciences: that is your choice. International Journal of Social Research Methodology, 16(5), 403–428.
3. Vidden, C., Vriens, M., & Chen, S. (2016). Comparing clustering methods for market segmentation: A simulation study. Applied Marketing Analytics, 2(3), 225–238.
4. Glatman-Freedman, A., Kaufman, Z., Kopel, E., Bassal, R., Taran, D., Valin-sky, L., et al. (2016). Near real-time space-time cluster analysis for detection of enteric disease outbreaks in a community setting. Journal of Infection, 73(2), 99–106. https://doi.org/10.1016/j.jinf.2016.04.038 PMID: 27311747.
5. Raschka, S. (2015). Python Machine Learning. Birmingham, UK: Packt Publishing.
6. Tyler, T. Y., & Zhang, M. M. (2011). Multivariate analysis of foreign direct investment in China. Journal of Applied Business Research, 23(2), 21–30.
7. Bangladesh Bureau of Statistics (BBS) & United Nations Children's Fund (UNICEF). (2019). Bangladesh Multiple Indicator Cluster Survey 2019. Progotir Pathey. Final Report. Dhaka, Bangladesh: BBS and UNICEF Bangladesh.
8. Bangladesh Bureau of Statistics (BBS) & United Nations Children's Fund (UNICEF). (2019). Bangladesh Multiple Indicator Cluster Survey 2019. Progotir Pathey. Key District Level Findings. Dhaka, Bangladesh: BBS and UNICEF Bangladesh.
9. Bangladesh Bureau of Statistics (BBS). (2022). Population and Housing Census 2022 (National Series—Volume 4).
10. Kaufman, L., & Rousseeuw, P. J. (1990). Partitioning around medoids (program pam). Finding groups in data: an introduction to cluster analysis, 68–125.
11. Maechler, M., Rousseeuw, P., Struyf, A., Hubert, M., & Hornik, K. (2018). cluster: Cluster Analysis Basics and Extensions (R package version 2.0.7-1).
12. Handl, J., Knowles, J., & Kell, D. B. (2005). Computational cluster validation in post-genomic data analysis. Bioinformatics, 21(15), 3201–3212. https://doi.org/10.1093/bioinformatics/bti517 PMID: 15914541.
13. Brock, G., Pihur, V., Datta, S., & Datta, S. (2011). clValid, an R package for cluster validation. Journal of Statistical Software (Brock et al, March 2008).
14. R Core Team. (2016). R: A Language and Environment for Statistical Computing. Vienna, Austria. Retrieved from https://www.R-project.org/.
15. United Nations Children's Fund (UNICEF). (2016). The State of the World's Children 2016: A fair chance for every child. New York, USA: United Nations Children's Fund (UNICEF).
16. World Health Organization (WHO). (2017-03-15). Early initiation of breastfeeding to promote exclusive breastfeeding. Retrieved from http://www.who.int/elena/titles/early_breastfeeding/en/.
17. World Health Organization (WHO). (1985). Appropriate technology for birth. Lancet, 2(8452), 436–437. PMID: 2863457.
18. World Health Organization (WHO). Skilled attendants at birth.
19. Das, S., Alcock, G., Azad, K., Kuddus, A., Manandhar, D. S., Shrestha, B. P., et al. (2016). Institutional delivery in public and private sectors in South Asia: A comparative analysis of prospective data from four demographic surveillance sites. BMC Pregnancy and Childbirth, 16(1), 273.

20. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. (2021). Bangladesh Demographic and Health Survey 2021. Dhaka, Bangladesh and Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.

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