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A Non-Invasive Approach for Anemia Eradication Through Community Based Mass Screening of Rural Population

Partha Pratim Das Mahapatra[1]*, Chaitali Roy[2], Sudip Roy Chowdhury[3], Pritam Sahoo[4], Piyali Das Mahapatra[5]

ABSTRACT

Background: Anaemia has been a major issue all over the world. More so ever, its impact can be seen in the regions with poor resource settings. In developing countries like India, it becomes a major highlight to determine some effective and affordable health care solutions, which could be accessible for people of all economic groups. This study was conducted with a purpose to determine the prevalence of anaemia as per the no-invasive device which will help in the preliminary screening for anaemia among the rural population. **Methods:** A cross-sectional study was conducted on 1637 individuals of Barchana sub-centre of Jajpur district, having age 5 years and above. Individuals demographic details like age, gender and other details like drinking water source, smoking habit, etc. were captured using the mobile app of the EzeCheck device. **Results:** The rate of prevalence of anaemia was found to be highest (75.7%) among the women population having age> 15 years, which was followed by children (53.8%) aged 5-11 years, 47.6% in children aged 12-14 years and lastly 36.3% among male individuals of age 15 years and above. No significant association was observed between the anaemia prevalence and drinking water source habitat. **Conclusion:** Our findings suggest, anaemia is a widespread disease among the rural parts of the country, which needs screening on regular basis to determine its status. But due to lack of proper healthcare facilities in under-developed areas as well as phobia of needles among individuals especially children, regular monitoring for anaemia is difficult. In such cases, we need non-invasive approaches which could help us determine the haemoglobin levels for easy and effective monitoring for anaemia.

[1]Chief Executive Officer, EzeRx Health Tech Pvt. Ltd.
[2]EzeRx Health Tech Pvt. Ltd.
[3]EzeRx Health Tech Pvt. Ltd.
[4]EzeRx Health Tech Pvt. Ltd.
[5]EzeRx Health Tech Pvt. Ltd.
*Corresponding Author

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One fourth (1.62 billion) of the world's population are affected by anaemia and 55% of Indian women population are anaemic [1]. Anaemia is defined as the reduction in haemoglobin content (less than 13.5 g/dL in men; less than 12.0 g/dL in women) or haematocrit (less than 41.0% in men; less than 36.0% in women) from an individual's body [2]. Lack of Haemoglobin content can cause several health issues and can lead to increased rates of morbidity and mortality. Anaemia affects the overall functionality of an individual as it causes decreased work productivity rate, impaired neurological development, and stunted development, due to the decrease in the oxygen supply to the tissues which affects the overall as well as organ functionality. Estimates have shown that, children and women of reproductive age group are utmost at risk of developing anaemia. According to the World Health Organization (WHO), in India, the prevalence of anaemia estimates to be 47% in children below 5 years and 53% in women within the age group of 15–49 years. Several initiatives have been taken to eradicate anaemia from its root cause, but the target of those strategies is yet to be achieved. The WHO Global Nutrition Target 2025 aims to reduce anaemia in women of reproductive age by 50% by 2025 [3]. To achieve the target, one needs to understand about the complexity associated with anaemia to implement effective solutions for anaemia eradication. Certain findings have shown that the prevalence of anaemia is more in the low socioeconomic groups as compared with the other groups [4] [5]. In rural areas due to poor resource settings, unfeasible access to routine biochemical and haematological testing, knowledge gaps and lack of simple and cost-effective technology, the goal to achieve the target becomes questionable. In such situations, arises the need for effective and easy to use screening methods for early detection of anaemia. For this study, we have used EzeCheck device, which is a non-invasive, portable, screening device which connects with the EzeCheck mobile app to determine the Haemoglobin levels (g/dL). As, anaemia is socially patterned by education, occupation, etc. and certain physiological characteristics like age, gender, pregnancy status, as well as environmental factors such as smoking, drinking water habitat and altitude affect, [6-8] so the app provides the option to store these additional information as well for future references. Crucially, the timely availability and accuracy of the captured data, its routine use for decision making, and assessing the effect, will underlie the successful implementation of anaemia control strategies.

METHODS

The study was done among the heterogenous group of 1637 individuals, residing at the Barchana Sub Centre of Jajpur District. Samples were collected randomly as we did not restrict the individuals from being assessed using any criteria except those who declined a verbal consent were not assessed using EzeCheck. Our samples included participants across all age groups starting from age of five years and above. Individuals under the age of five years were not involved in the assessment since the EzeCheck finger sensor was not designed for them. We

assessed consecutive individuals as per operational feasibility. Verbal informed consent was obtained from each of the participants (in case of individuals less than 18 years of age, consent was taken from the individual along with the consent from either parent or guardian) before measuring their haemoglobin using EzeCheck (Fig:1).

EzeCheck: A non-invasive portable device which can detect anaemia instantly without taking a single drop of blood from the human body. Device has four main components- Printed Circuit Board (PCB) with the sensor, mobile application, web application and the Artificial Intelligence (AI) Algorithm. EzeCheck uses a cool white LED light which projects into your left-hand ring finger and measures the intensity of reflection received. This reflected signal is then sent to the EzeCheck Mobile Application which connects the received data to the server where a series of AI algorithm are run to analyse the biomarkers present in the received signal to give the output of the Haemoglobin (Hb) in g/dL. This generated output is then sent back to the EzeCheck application and is displayed to the user.

Fig:1 Non-invasive haemoglobin screening device- EzeCheck

The study used EzeCheck app to collect the information of participants about the different variables, like personal, socio-demographic, pregnancy history, family history, medical history, and lifestyle habits. The EzeCheck device was connected with the mobile app through Bluetooth connectivity. After entering the user details, the device was set to capture the signal using the absorption spectrometry and then the device ran a series of signal processing techniques at the backend by the machine learning algorithm to generate the haemoglobin value for that participant. The whole process took around 30-45 seconds and each of the participant was measured only once.

Data analysis was done using the Microsoft Excel. Percentage, mean, Standard deviation (SD) and correlation were applied for the descriptive analysis. The correlation between variables was established using t-test. A p-value of 0.05 was considered as significant with a 95% confidence interval. Informed verbal consent was obtained before conducting the study and complete confidentiality was ensured. We used the sex and age-specific WHO criteria as cut-offs: children aged 5-11 years with Hb <11.5 g/dL, adolescents aged 12-14 years with Hb <12 g/dL, men aged ≥15 years with Hb < 13.0 g/dL and women ≥15 years with Hb <12.0 g/dL were categorized as 'anaemic' and the rest as 'non-anaemic' [9].

RESULTS

A total of 1637 individuals having the age in range of 5 to 80 years, were screened for knowing the haemoglobin values using the Non-invasive device. 53.26 % of the studied population were female and rest 46.74 % were male. We categorized the entire population into 4 major categories depending upon the age groups: Children aged 5-11 years of age (n=555), adolescents aged 12-14 years (n=493), women aged ≥ 15 years (n=317) and men aged ≥ 15 years (n=272) [10]. The mean age of the respective groups was 9, 12.6, 30.8 and 25.9 years respectively. 72.02% (n=1179) of the studied population had government supply, 23.7% (n=388) had natural (tube well or well) and 2.5% (n=41) had Reverse Osmosis (RO) water filter as their drinking water source while the rest 1.78% (n=29) were unknown about their water source. Distribution of water source in anaemic population has been depicted in Fig:3. Age-wise anaemic status has been shown in Table 1. The association between the drinking water source and prevalence of anaemia was found to be statistically significant (p-value < 0.001).

53.87% of children aged 5-11 years, 47.66% of adolescents (12-14 years), 75.7% of women having age ≥15 and 36.3% of men aged ≥15 years were found to be anaemic (Fig:2). Only 46.67% of the entire population were found to be non-anaemic. The association between gender and anaemia prevalence was found to be statistically significant (p-value =0.002) with 60% of anaemic population being female. The severity of anaemia among the women anaemic population having age greater than or equal to 15 years, has been shown in Fig:4. The mean haemoglobin level was found to be 11.46 g/dL for children aged 5-11 years, 12.04 g/dL for 12-14 years adolescents and 10.4 g/dL, 12.9 g/dL for women and men ≥ 15 years of age respectively. All individuals were aware of the test and were tested single time during the entire study period.

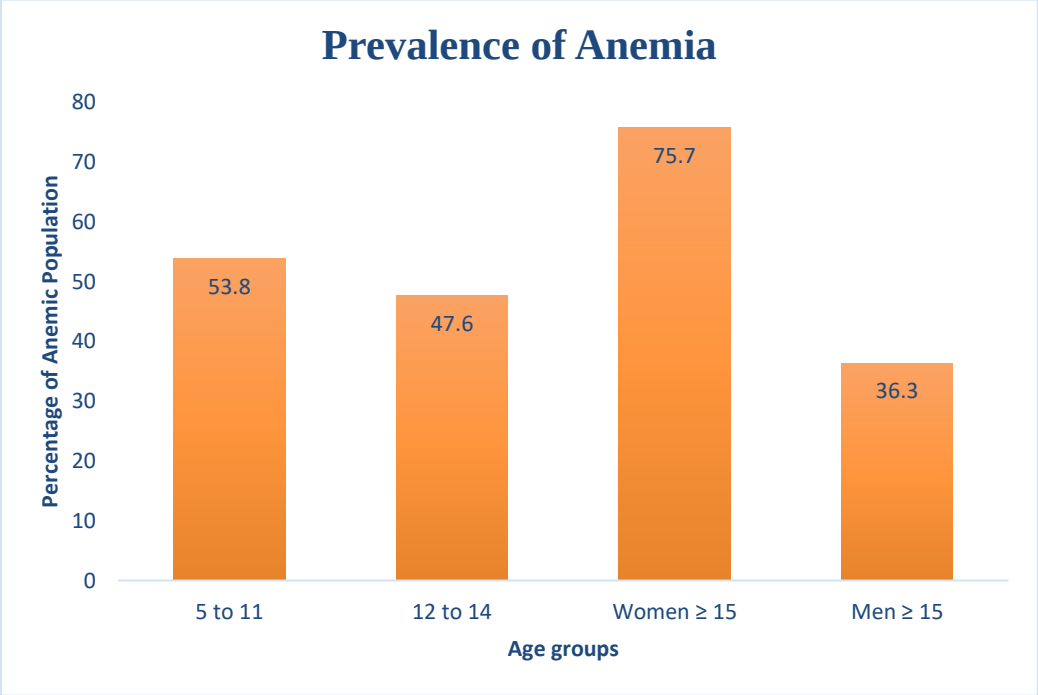

Fig: 2 Prevalence of Anaemia across different age groups

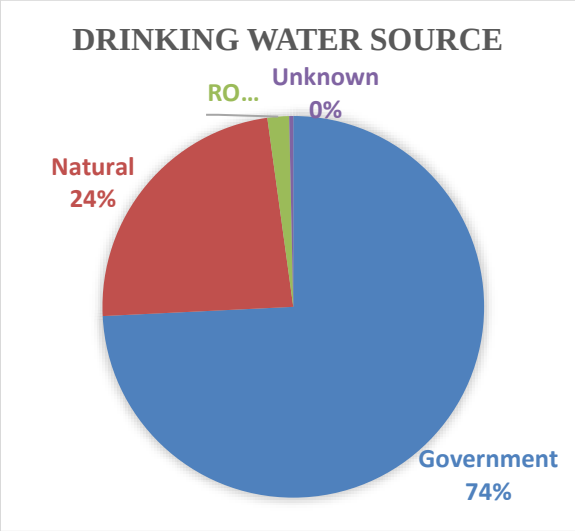

Fig: 3 Distribution of water source among the anaemic population.

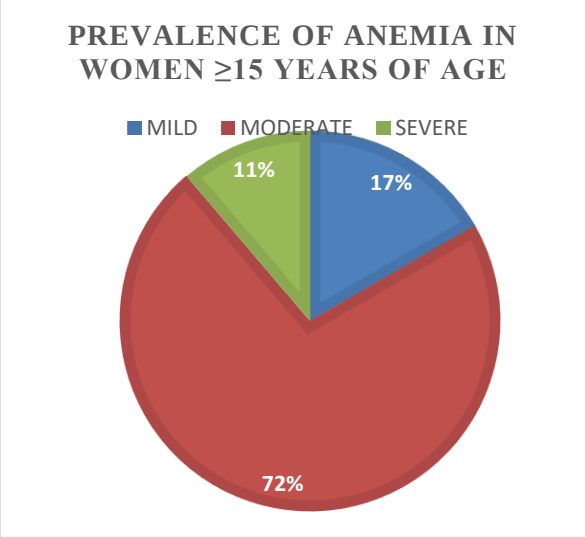

Fig: 4 Severity of anaemia among anaemic women having age ≥15 years.

Age Group	No. of individuals	Anaemic
5 to 11	555	299
12 to 14	493	235
Women ≥ 15	317	240
Men ≥ 15	272	99

Table 1: Anaemia status of different age groups as per EzeCheck

DISCUSSION

Anaemia has become a common disease affecting 1.8 billion people across the globe [11]. Considering the Indian scenario, findings have shown that, out of 28 states, 16 states had a higher prevalence rate for anaemia (>55%) which was found to be majorly among the Schedule Caste, Schedule Tribe, and Other Backward Castes women, while in the other 13 states, majority of the anaemic women belonged to general category [12]. As per the National Family Health Survey-5, the prevalence rate of anaemia in Odisha was found to be more than 55 % which involved the girl children and the women population (pregnant & non-pregnant) [13]. Certain factors like lack of education, poor diet, lack of awareness, inaccessible health care facilities, lack of proper hygiene leading to infections, etc. are some of the major factors that contribute to anaemia which can also be observed among the children below 5 years of age. Anaemia is a disease which is a major cause of concern for all the countries because of its complexities. Prolonged and untreated anaemia can adversely affect one's immune system, causing them more prone to illness. As the organs are unable to get proper amount of oxygen, so heart or lungs related complications can also occur which can even lead to organ failure. Pregnant women with severe or untreated anaemia are found have higher risk of complications which will adversely affect the new-born's health as well. Studies have revealed that due to poor demographic and socioeconomic indicators, Odisha is among the eight sanctioned action group states. A survey conducted in Odisha had revealed that 71-81% of anaemia are found among the children under 5 years and 5-9 years of age [17].

Several initiatives have been taken by the government and non-government organizations to tackle the situation, but they are facing certain bottlenecks in achieving the desired target. In developing countries like India- Poverty, illiteracy, lack of proper healthcare facilities in rural areas, cost-effective solutions are some of the most important points which need to be addressed while implementing any strategy. In this approach, proper and timely screening for the anaemia prevalence could be the first and major step towards anaemia eradication. Generally, several methods are available to know the Haemoglobin level but one of the most widely accepted one is the automated analysers, which are considered as the gold standard method,[18] which although have several limitations, making it unsuitable for the rural areas [19]. As the use of Haematology analysers is an expensive method and requires electricity for its operation, so in certain Indian villages, methods such as Sahli's technique, copper sulfate method, Colorimeter, and HemoCue

are still used for the detecting anaemia [20]. Although being cost-effective, these methods require qualified and trained professionals for drawing blood, a proper laboratory setup, and proper preservation of the samples, which becomes a difficult task for the resource-poor settings [21]. For such situations, point of care screening devices can be helpful.

In our study, we have focused a rural area of Odisha where the anaemia prevalence is highest with 83.1% among the school children [14]. Recent studies have revealed that the anaemia status for the Jajpur district is very much concerning as it is one among the districts whose anaemia status has worsened since last six years. Not only the children, even the prevalence rate was found to be high for the pregnant women also compared to other districts of Odisha [15]. We corroborated the similar pattern for anaemia using the non-invasive haemoglobin screening device. Mostly the women and the children population were found to be affected. The sole purpose of this study was to determine the chances of anaemia among the rural population of Jajpur, Odisha, which can help the responsible authorities in taking appropriate decisions for eradicating anaemia. The simplicity, portability and ease of use makes the device more promising; the generated output can be referred to a city-based hospital easily as the device is IoT enabled and the generated pdf report can be shared through any messaging app. Along with serving the humanity, the device is also eco-friendly as it doesn't generate any sort of biomedical wastes like syringes, bandages, vials, etc. Although certain point of care devices like HemoCue are available which has reduced the time for sample processing and result generation, [16] but it requires blood sample, chemicals and microcuvettes for obtaining the results. Another study conducted on the school children using the Mission plus haemoglobinometer indicated that certain factors like skin thickness, pressure while pricking and the temperature were the major obstacles for the technology which affected the results [22-24]. Unlike other devices, the non-invasive EzeCheck device required no use of chemicals, cuvettes, or blood sample for determining the Haemoglobin values.

Our study has certain limitations like data for additional variables like pregnancy status, Iron and Folic Acid supplementation, marital status, etc. were not available with us, which may have an impact on the anaemia status. Children below 5 years were not included in this study, so the estimate of anaemia prevalence for that particular age group can't be known. Also, the device can be used only for the preliminary screening purpose to detect the chances of anaemia in an individual, for diagnosis or further treatment, one needs to correlate the obtained Hb result with the laboratory results. Despite of these limitations, we were able to find a high prevalence rate for anaemia among the individuals of Barchana sub-centre. Our observed results were in concordance with the previously available data which indicates high levels of anaemia prevalence in the Jajpur district.

CONCLUSIONS

This study revealed a very high prevalence of anaemia among the women population aged 15 years and above. Lack of timely intervention could worsen the situation and may lead to adverse health consequences. The goal of this study is to determine the prevalence of anaemia using the non-invasive method which can help to better identify and design strategies to prevent and treat anaemia especially among the vulnerable population like women and children.

EzeCheck is a handy, portable, pain-free, and cost-effective, non-invasive screening device which can be used easily to get instant haemoglobin results. Regular use of such devices across different geographical regions where the medical facilities are not well-developed, could help in early detection and prevention of anaemia at primary level.

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Conflict of Interest

The author(s) declared no conflict of interest with respect to the research, authorship, and publication of this article.

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