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Original Article

An efficient and effective ambulatory service model for severe hemophilia-A patients; an introduction to a novel home care model

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Abstract: Introduction: Hemophilia A (HA) is an inherited deficiency in blood coagulation factors. Starting the treatment based merely on patients' hemorrhage feelings results in more than 63.6% mistakes in joint bleeding diagnosis. This study aimed to design a useful ambulatory service model for Patients With Severe Hemophilia A (PWSHA). Methods: This study was done in 3 steps. In step-I, the current service model to PWSHA in Tehran was evaluated. In step II, an ambulatory service model was proposed according to the existed gaps and their requirement. In step III, the model's acceptability was assessed from the perspective of clinicians, PWSHA, and healthcare policymakers. Results: There were 1660 PWSHA in Tehran in 2018. The average use of Factor VIII (FVIII) was 44814 IU in Iran. The yearly budget of FVIII in Tehran was 10,627,320 US$ in 2018. We proposed a home care model with five care centers in Tehran. Ten caregivers and three hematologists for each care center were suggested to cover all services per day. The extracted data indicated that the total service demand would be 39 for each center per day. The results of the questionnaires in all groups were supportive and cooperative. Conclusion: The current service delivery model to PWSHA has significant economic and clinical defects. Implementing our model can significantly improve the efficiency of bleeding management in PWSHA. Most of the PWSHA, healthcare managers, and clinicians were satisfied with the proposed model.

Keywords: Haemophilia A, factor VIII, health service model, efficiency

Introduction

Hemophilia is an inherited bleeding disorder caused by a lack of clotting factors. Hemarthrosis is the most frequent manifestation of hemophilia, which results in chronic arthropathy and leads to pain, joint destruction, and impaired mobility [1]. HA is the typical type of hemophilia caused by a low concentration of FVIII and is classified into three levels according to coagulation factor activity; severe (<1%), moderate (1-5%), and mild (>5-30%) [2]. The Iranian ministry of health statistics show that 82% of hemophilia patients in Iran suffer from FVIII deficiency, 60% of them are classified as severe HA [3]. HA is one of the high-cost diseases for societies because of three reasons. First, HA is a lifetime disease. Second, the cost of the factor concentrates is very high, especially when the FVIII inhibitor is developed. Third, the management of complications of the disease is costly [4].

Studies showed that factor replacement therapy is the main cost driver of hemophilia management (around 67%) [5, 6]. Thus, any idea for optimizing drug use in PWSHA can effectively affect the use of resources, including medicine and budget.

Two main protocols are currently defined for managing the PWSHA's muscle-skeletal bleeding; episodic or on-demand and prophylaxis protocols. Prophylaxis protocol can be started

after recognizing the first symptoms of bleeding by the patients [5], described as a tingling sensation or aura [1]. In on-demand protocol, any bleeding episode is managed directly by the patients at home. That means hemorrhage is usually recognized by the patient's perception of hemorrhage and pain, and factor concentrate is infused in the home setting to allow for early treatment of a bleeding episode [5]. However, the point to be considered is that treatment based on the patients' perception alone can be up to 63.6% wrong in the joint bleeding diagnosis [7]. This could, in turn, lead to 63.6% misuse of clotting factors and financial resources. Thus, it is quite logical and necessary to propose a new service model to reduce mistakes and improve the efficient use of financial resources in managing HA.

Ultrasonography is considered a safe and reliable imaging facility for diagnosing and monitoring joints disease [8]. This diagnostic method can be used to confirm joint bleeding before starting medical therapy [1, 9, 10]. Nonetheless, since ultrasonography is generally provided in hospitals, the costs, acceptability, and feasibility of using this technology to diagnose and monitor joints bleeding should be considered carefully.

Iran has the ninth-largest population of HA in the world [11]. The prevalence rate of HA was 14 in 100,000 males in 2009 [10]. Almost all adult PWSHA and most of the hemophilic children in Iran are under episodic (on-demand) treatment protocol [11, 12]. However, secondary prophylaxis and home therapy are provided for some of the PWSHA with joint bleedings [1, 9]. The annual medication cost for all severe Hemophilia A patients was nearly 28,571,000 US$ in 2016 in Iran [3]. This study aimed to design and evaluate the acceptability of an ambulatory service model for PWSHA in Tehran, Iran.

Method

We used mixed methods to benefit pragmatic results. This study was performed in 3 steps.

Step I

The current method of FVIII delivery to the Iranian adult PWSHA was reviewed. This step was done by investigating different sources, including Iranian guidelines for managing HA, recorded data in related governmental organizations, documents in health insurance organizations, and the Iranian Hemophilia Comprehensive Care Center (IHCCC). In this step, the primary protocols of diagnosis, the number of PWSHA in Tehran, the process of health service delivery to the patients, the quantity of FVIII for each patient, the total budget of FVIII in Tehran, and managing emergencies were assessed. The review of these documents showed the potential defects and probable sources of inefficiency in the existing service delivery model.

Step II

A new model of service delivery was designed. For this purpose, the practical method of distinguishing hemorrhage, the golden time for managing bleeding in PWSHA, distribution of the patients across the city, the required number of care centers, the type and number of human resources, the type and amount of equipment in care centers, and the number of caregivers were estimated. These estimates were based on the findings of step-I and were completed by interviewing relevant experts. These experts included radiologists, hematologists, emergency workers, human resource managers, nurses, and traffic engineers.

Step III

The acceptability of the model was evaluated by clinicians, health care managers, and the PWSHA. Three researcher-made questionnaires were designed to assess the subjects' views on the proposed model. The clinicians and health care managers' questionnaire had ten questions, but the patients' questionnaire had nine questions. The results of the questionnaires were analyzed and considered for potential model modification.

Results

Our findings are presented in three subtitles; the current service model, new service model development, and the new service model's acceptability.

Current service model

There were 1660 PWSHA in Tehran in 2018. They had a monthly FVIII quota, which they were getting by referring to the distinguished

hospital pharmacies. The review of the patients' documents in IHCCC indicated that PWSHA were getting extra FVIII for some exceptional situations like referring to a dentist, physiotherapy, and surgery. The clinicians examined them before getting the excess amount of FVIII to confirm their eligibility. Documented data in Iran Food and Drug Administration (IFDA) indicated that the average use of FVIII per patient per year was 44814 international units (IU) for PWSHA in Iran. Considering the average weight of PWSHA, this figure demonstrated that the annual budget of FVIII in Tehran was 10,627,320 US$ in 2016 [3]. All adult PWSHA start home therapy to manage their bleedings based on their feeling of hemorrhage and pain. Therefore, they are also at the risk of the wrong bleeding diagnosis and are more likely to use almost 64% of FVIII more than needed [7]. This should be considered as one of the tremendous and effective defects in the current model of FVIII delivery to PWSHA. In other words, the main problem of this model is the lack of correct diagnosis of bleeding.

Besides, the results of interviews with PWSHA showed that many of them do not know the exact dose of FVIII and then inject it almost carelessly. Also, many parents of PWSHA stated that they have difficulty injecting FVIII into their children.

The interview results with hematologists revealed that some of the PWSHA, which are addicted to opioids, sell their received factors in the black market to receive some money for their daily use. Though the exact rate of this smuggling is unknown in Iran, the recorded data in IFDA supported this claim. Likewise, there have also been few reports in IFDA, which shows that a considerable amount of FVIII had expired in the patients' homes.

The results of our literature review showed that ultrasound is a highly effective method for distinguishing bleeding with other pain episode's etiology like hemarthrosis [1, 12, 13]. Ultrasound is also considered a reliable and efficient protocol for the monitoring of bleeding [8]. Moreover, it is stated in the literature that the bleeding in PWSHA should be treated within two hours [6]. Thus, the golden time for accessing PWSHAs and stopping potential bleeding should be less than two hours.

Service model development

The first step in our model development was to design a practical method of bleeding diagnosis. As shown above, the current model's main problem is the lack of accurate diagnosis of bleeding. Ultrasound service is one of the best options for distinguishing bleeding. However, because ultrasound services in hospitals and imaging centers require prior planning, this process is not as convenient as home therapy. Thus, we considered a mobile ultrasound service to diagnose the bleeding accurately.

In accordance with the information received from emergency officers and traffic engineers and also taking into account the golden time of service delivery, we proposed five care centers in north, south, west, east, and the center of Tehran. All of them are suggested to be located in specified hospitals.

The amount of equipment and number of required caregivers for each center was estimated based on two elements; the required number of services and each service's duration. The number of services required was projected based on the potential number of bleedings per day. According to the Iranian ministry of health's national registry database, the median annual bleeding rates were 42 (3.5 per month) for patients managed by the on-demand protocol, almost like other countries [14, 15]. Therefore, the expected number of hemorrhages per month in Tehran could be 5810 (1660 * 3.5). That means each health care center should respond to 1162 requests per month (39 requests per day).

As most of the bleeding occurring due to physical activity, we assumed that 50% of the services would be demanded between 8 AM to 4 PM (almost 20 services), 30% between 4 PM to midnight (almost 12 services), and 20% between midnight to 8 AM (almost eight services).

Each service's duration includes arrival time to the patient, the preliminary examination of PWSHA, sonography, drug injection, and returning to the care center. According to the information received from emergency officers and traffic engineers, each service will last between 1 to 2 hours in Tehran. Thus, each service will

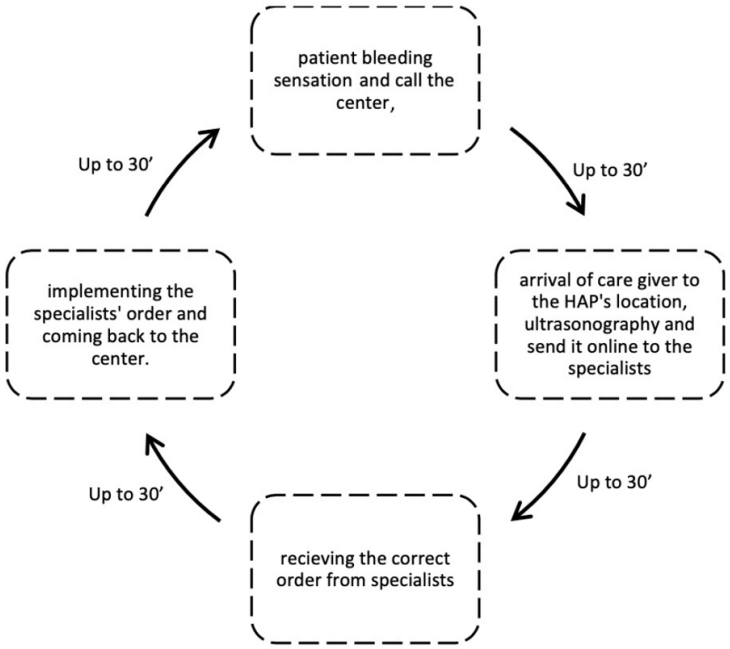

Figure 1. Process of the suggested model.

Table 1. The total number of required nurses and radiologists per day for each center

Working shift	Number of trained Nurses	Number of Radiologists
Mornings (8 AM-4 PM)	5	1
Afternoon (4 pm Midnight)	3	1
Night (Midnight-8 AM)	2	1
Total	10	3

take place on average, around 1.5 hours (**Figure 1**).

Based on the probable number of requested services in each working shift and the average time for each service, we considered ten caregivers (trained nurses) for each care center to cover all services per day. In the same way, five courier cares were considered for each care center. Each caregiver is responsible for meeting the needs of the patients who contact the center. Our interviews with hematologists and radiologists suggested having one radiologist in each center for diagnosing musculoskeletal bleeding to ensure that patients' bleeding is correctly diagnosed. Caregivers have the facility to communicate with the care center online to share their complex cases. Thus, we considered a radiologist in each center. The details of the distribution of human resources per day for each center are presented in **Table 1**.

The type and number of the equipment for the model were estimated based on the patients' needs. The equipment was divided into two groups; equipment for care centers and equipment for courier care. The equipment for care centers was mainly office equipment. The main equipment for courier care was the appropriate motorcycle, portable ultrasound machine, and tablet. The type and number of equipment are presented in **Table 2**.

The cost of running the proposed model was estimated based on the type and the number of human resources, equipment, and medical services. The details of costing and its analysis are presented elsewhere [16]. However, the annual budget of the two service deliveries' costs is shown in **Table 3**.

The service delivery process in our proposed model begins with patients contact. After the perception of bleeding, the PWSHA calls the center and asks for care. The care center quickly sends a courier (a trained nurse) to the patient. The trained nurse examines the patient, does ultrasonography, and sends the sonography result online to the center to consult with a radiologist if needed. The caregiver would inject FVIII into the patient if he needed it. The caregiver provides patients with additional advice and care based on the patient's needs. The caregiver returns to the center to get ready for the next mission. The duration and process of the suggested model are presented in **Figure 1**.

The acceptability of the new service model

The suggested model's acceptability was evaluated by the 50 patients, 16 clinicians, and 12 health care managers. The questionnaires' results showed that 96% of the patients expected that the suggested model reduce their side

Table 2. Total number of human resources and required equipment

Type of resources	Resources in each care center	Total
Human resources for each care center		
Trained nurse	10	50
Radiologists	3	15
Equipment for each care center		
Desk, resting staffs, and online devices for physicians	1	5
Medical refrigerator	1	5
Equipment for each courier care		
Online portable sonography	6	30
Injection set	6	30
Motorcycles	6	30
Online tablets	6	30

Table 3. Costs of the traditional and proposed model

health service delivery model	Annual Cost US$		Annual Saving US$	
Existing Model	Per patient	total	Per patient	total
	6,627 $	11,001,816	---	---
Proposed Model	Per patient	total	Per patient	total
	2,764	4,589,247	3,863	6,412,569

Table 4. Results of patients, clinicians, and health care managers

Questions	patients		Clinicians		Health care managers	
	Yes	No	Yes	No	Yes	No
1. Are you satisfied with the current method of service delivery?	34%	66%	NA	NA	NA	NA
2. Are the types and the numbers of specialists are ample for your services?	28%	72%	50%	50%	75%	25%
3. Can the suggested model improve the quality of the health care system that provided?	6%	94%	68.75%	31.25%	50%	50%
4. Can the suggested model prohibit the extra use of Factor VIII?	10%	90%	NA	NA	NA	NA
5. Although you diagnose the bleeding yourself, can examination with the ultrasonography devices improve the accuracy of the real cause of your pain episode?	4%	96%	NA	NA	NA	NA
6. Can the suggested model reduce your side fees? (like your travel costs).	96%	4%	NA	NA	NA	NA
7. Is the process of the suggested model logical and suitable?	98%	2%	75%	25%	75%	25%
8. In general, is this model logical and appropriate?	100%	0%	81.25%	18.75%	75%	25%
9. Is it better to want the specialists to order online from anywhere? Rather than just from the distinguished hospital centers?	NA	NA	75%	25%	83.33%	16.66%
10. Is the trained nurse proper to implement ultrasonography?	NA	NA	62.50%	37.50%	NA	NA
11. Can you consider a suitable space in the governmental hospitals for the centers?	NA	NA	100%	0	100%	0

NA: Not Applicable; means this question was not asked from this group.

fees. Almost all of them (98%) believed that the model processes are suitable, and all of them (100%) believed that the model was "generally reasonable and appropriate". The details of the results of the questionnaires are presented in **Table 4**.

Discussion

This study aimed to propose an effective ambulatory service model for PWSHA in Tehran. Hemophilia is a high cost and lifetime disorder that directly and significantly impacts patients and governments [12, 17]. Nearly 67% of hemophilic expenses are due to their pharmaceuticals [3].

The current medication therapy model for the PWSHA in Iran could be considered a home care model. Since the 1970s, the home care model has been introduced to treat mild and moderate bleeding cases in trained patients.

However, this model of therapy has different non-economic risks and benefits. It is showed that, generally, home treatment for PWSHA could provide early access to clotting factors, 89% reduction in hospitalization, 74% decrease in absenteeism at work, 76% reduction in the outpatient visit, and 45% in healthcare costs [18-20]. Nonetheless, it has some serious risks and disadvantages, including improper factor dose, neglecting the severe bleedings, failure to distinguish adverse reaction to FVIII, loss of FVIII's potency as a result of unsuitable storage or outdated factor, infection or damage to veins, injuries triggered by incorrect needle disposal, pain and disability due to delayed treatment, and parents' problem to needle their children [21]. The episodic protocol for managing the muscle-skeletal bleeding in Iran, is very similar to home care therapy for hemophilia patients and therefor it is expected to have the same advantages and disadvantages of this model for managing bleeding in PWSHA.

One of the additional challenges of the current health service delivery model to the PWSHA is the considerable overuse of medicine (more than 63% of FVIII), which is attributable to the lack of proper bleeding diagnosis. Therefore, the most crucial advantage of our model is to eliminate this problem.

Our proposed model can be a home care therapy because the required services are provided at home. Nonetheless, due to the consideration of portable ultrasound and accurate diagnosis of bleeding in the model, proper calculation of FVIII dose, disinfected injection of the drug into the patients, and proper needle disposal, our model, can retain all advantages of home care therapy and cover almost all risks and disadvantages of this model. In addition, as the overuse of FVIII will be controlled in our model, the adverse reactions of FVIII will also be decreased. This can both improve the quality of life of the PWSHA and save significant financial resources.

Another advantage of our model is that the medication therapy in PWSHA could be started in less than one hour, entirely within the treatment's golden time (less than two hours) [8]. Also, as the point-of-care examination for assessing painful musculoskeletal episodes in hemophilic patients is considered in the model (ultrasound imaging), PWSHA does not need to go to the hospital for acute bleeding or trauma. This can help patients get closer to a normal lifestyle.

The cost-minimization analysis results showed that our proposed model could save 58.29% of the budget spent on FVIII, as the model's running cost is 5.31% of the annual cost of FVIII for PWSHA (**Table 3**). The details of this economic evaluation are presented elsewhere [16].

An essential part of the model development was the model acceptability assessment. The results of our acceptability questionnaires showed that although the clinicians believed that one of the biggest obstacles of the model would be low compliance of the patients, 100% of the patients were optimistic about the implementation of the proposed model. PWSHAs declared that this model could increase their comfort predominantly. One of the reasons for this could be that they cannot easily take FVIII with them to school, work, party, and travel. Most of the PWSHA stated that they believed that the proposed model is more efficient than the existing service model because they know the exact time of factor injection in this model.

Some healthcare managers who were questioned disagreed with this model because they thought that running this service delivery is not affordable for the government. However, the result of our economic evaluation showed that this service delivery model not only does not require more budget but can also save 58.63% of the current annual budget for PWSHA [16]. Although some interviewees had concerns about implementing the proposed model, the questionnaires' results in all groups were supportive and cooperative. These could confirm that our model's acceptability has been validated by the PWSHA, the health care managers, and the clinicians.

Conclusion

The current service delivery model to the PWSHA has significant economic and clinical defects. These weaknesses have significantly affected PWSHA and the government. Our proposed model can effectively cover most of the existing home care model defects, improve the quality of life of the PWSHA, and save a significant amount of budget successfully. In other words, implementing our model can significantly improve the efficiency of bleeding manage-

ment in PWSHA. Almost all PWSHA, healthcare managers, and clinicians were satisfied with the proposed model and effectively confirmed its acceptability.

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Disclosure of conflict of interest

None.

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