



INTRODUCTION

Diabetes is a major public health problem worldwide, due to its increasing prevalence and the potentially serious complications it causes.

Diabetic retinopathy (DR) is the most common microvascular complication of diabetes, due to damaged retinal vessels. In Algeria, its prevalence was 18.99% in 2019¹. It represents a considerable economic burden, which could be avoided by early detection.

It is one of the world's five leading causes of blindness, and the first among people under 50², with Diabetic Macular Edema (DME) as the leading cause of visual impairment in the patients with type II diabetes³.

Artificial intelligence (AI) software is being developed to facilitate diagnosis, classification, monitoring and treatment of retinal conditions.

OBJECTIVES :

Estimate DR costs in Algeria.

Evaluate the economic benefit of early detection of DR. Evaluate the medico-economic benefit of AI-based automatic method in early detection.

METHODS

1- Estimation of DR costs in Algeria :

The estimation of economic burden was carried out based on:

The investigation results conducted at:

Algerian University Hospital Center in, in order to define the protocol care including medical examinations and treatments for each stage of the disease.

Four private ophthalmology clinics to calculate the average prices of ophthalmological examinations and treatments.

The prevalence of each stage of the disease was extracted from a study conducted by the Algerian Society of Diabetology (SADIAB)³.

$$\text{Economic burden} = \Sigma [((\text{examination price} \times \text{frequency}) + (\text{treatment price} \times \text{frequency})) \times \text{patient number in each disease stage}]$$

2- The economic impact of early detection :

Early detection of DR is the key to prevent progression to complex stages such as blindness in approximately 90% of cases⁴. The budget impact model of early diagnosis in Algeria was developed using the results of the DR mobile screening program implemented by the Federation of Health Centers of Alsace with the support of the regional health agency Grand Est in France, where no local data are available⁵.

According to the program's conclusions, the screening rate since 2017 calculated by relating the number of DR diagnosed to the number of people screened, amounted to 11%. Where 90% of DR cases are diagnosed at an uncomplicated stage, while 10% are identified at a complicated stage.

Extrapolating these figures on the Algerian eligible population for early diagnosis, 81,01 % of patients with type II diabetes who theoretically have not yet developed DR in Algeria, it is estimated that a certain number of patients are suffering from DR, among them there is a specific number are diagnosed at early stage. By treating these patients, it is possible to avoid complications and reduce the affected population, which will lead to cost reduction.

3- Budget impact model of the AI-based automatic method on early screening :

The budget impact model of screening program using AI-based automatic method compared to conventional methods, was carried out based on :

The United Kingdom software price and indirect costs (the equipment price, the assistant salary) for the automatic technique⁶, and the average prices for the conventional technique.

In this simulation, four different switch scenarios were introduced, wherein the conventional methods were substituted with the AI-based automatic method at different percentages, as presented in the following table :

Tab 1- Transition scenarios to the AI-based automatic method.

	2023	2024	2025	2026	2027
Scenario 1	10 %	15 %	20 %	25 %	30 %
Scenario 2	15 %	25 %	35 %	45 %	55 %
Scenario 3	25 %	40 %	55 %	70 %	85 %
Scenario 4	100 %	100 %	100 %	100 %	100 %

RESULTS

1 - Estimation of DR costs in Algeria :

The estimated economic burden of DR in Algeria in 2023 is more than 25.5 MUSDD, this cost was calculated using the price of examinations and treatments as well as the number of patients in each stage of the disease, deducted from the prevalence and population growth rate for new patients. The results are presented in the Table 2.

2 - The economic impact of early detection :

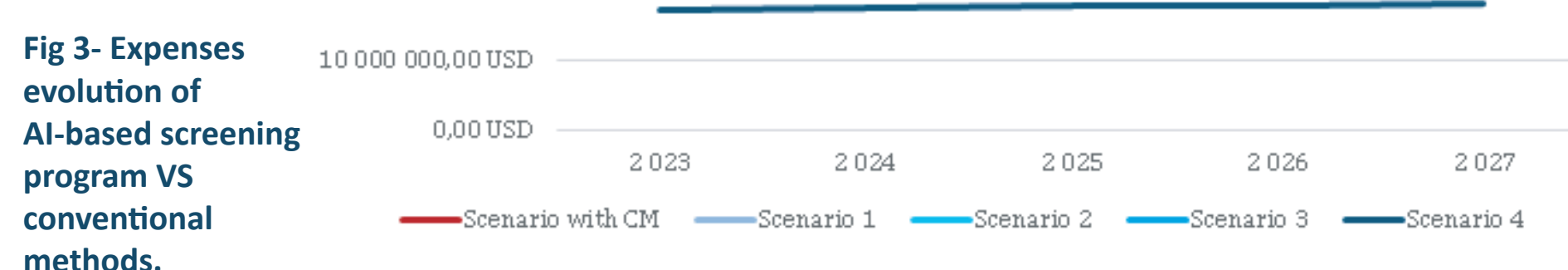
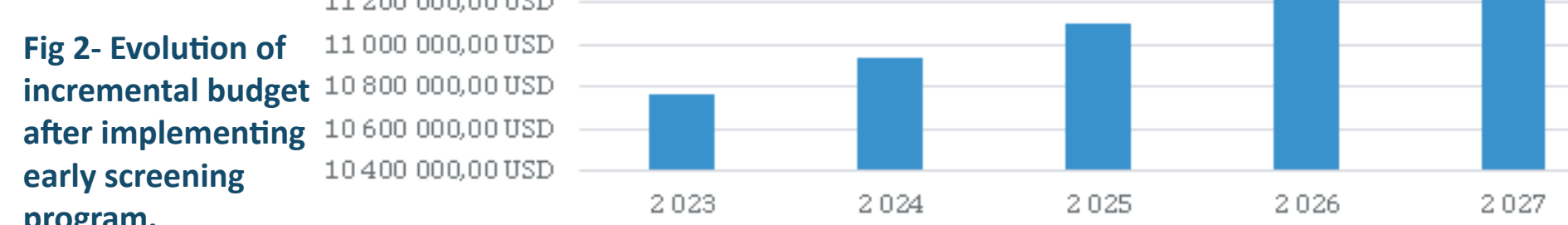
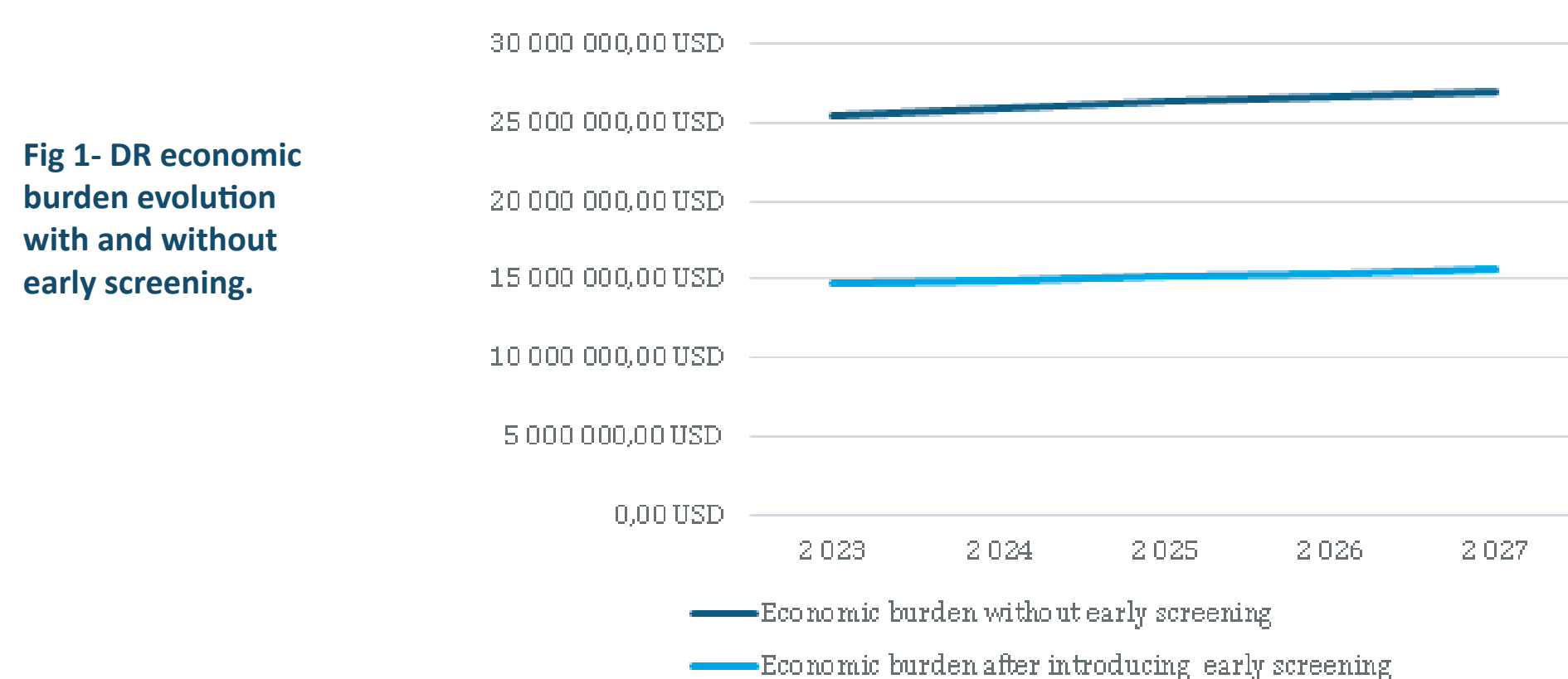
By applying the results of the mobile screening program to the Algerian population, the results in Table.3. Fig.1 were obtained.

The incremental costs for the five next years, are presented in Table.4. Fig 2.

3 - Budget impact model of the AI-based automatic method on early screening :

The economic impact of using the AI-based automatic method compared to the conventional methods is analyzed and presented in Fig.3, highlighting the specific results for each scenario considered.

The incremental budget that illustrates the savings achieved using the AI-based automatic method compared to conventional methods in an early detection program for DR over a period of five years Fig.4.



Tab 4- Incremental budget after implementing early screening program

Evolution	2023	2024	2025	2026	2027
Incremental budget after implementing early screening (USD)	10 770 158	10 939 739	11 104 462	11 264 558	11 420 721

Tab 2- Estimation of the economic burden of DR in Algeria.

Stage	Prevalence	Population	Unit Cost	Frequency	Operational population	Operational population costs
Total Algerian population (7)	100 %	46 553 000				
Adult population (18-69) (7)	57,52 %	26 777 286				
Population with diabetes (8)	14,40 %	3 855 929				
Population with DR (3)	18,99 %	732 241				
Population with DME (3)	3,80 %	27 825				
Mild NPDR	55,24 %	404 490	14,58	100%	404 490	5 898 074
Moderate NPDR	13,33 %	97 608	43,74	100 %	97 608	4 269 804
Severe NPDR	20,95 %	153 404	58,33	100 %	153 404	8947 476
Uncomplicated PDR	5,71 %	41 811	1 130,07	1,62 %	677	765 437
Complicated PDR	4,76 %	34 855	2 143,48	1,62 %	565	1 210 308
Mild DME	57,14 %	15 899	262,47	100 %	15 899	4 173 043
Moderate DME	33,33 %	9 274	379,12	1,62 %	150	56 959
Severe DME	9,52 %	2 649	4 214,06	1,62 %	43	180 838
					USD	25 501 939

Tab 3- Simulation of early DR screening impact on the patient's number and healthcare system.

	2023	2024	2025	2026	2027
Estimation of population with DR without early screening	732 241	743 770	754 970	765 854	774 471
Estimation of population with DR with early screening	422 996	429 656	436 126	442 413	448 547
Economic burden without early screening (USD)	25 501 939	25 903 479	26 293 516	26 672 597	27 042 365
Economic burden after introducing early screening (USD)	14 731 781	14 963 740	15 189 054	15 408 039	15 621 644

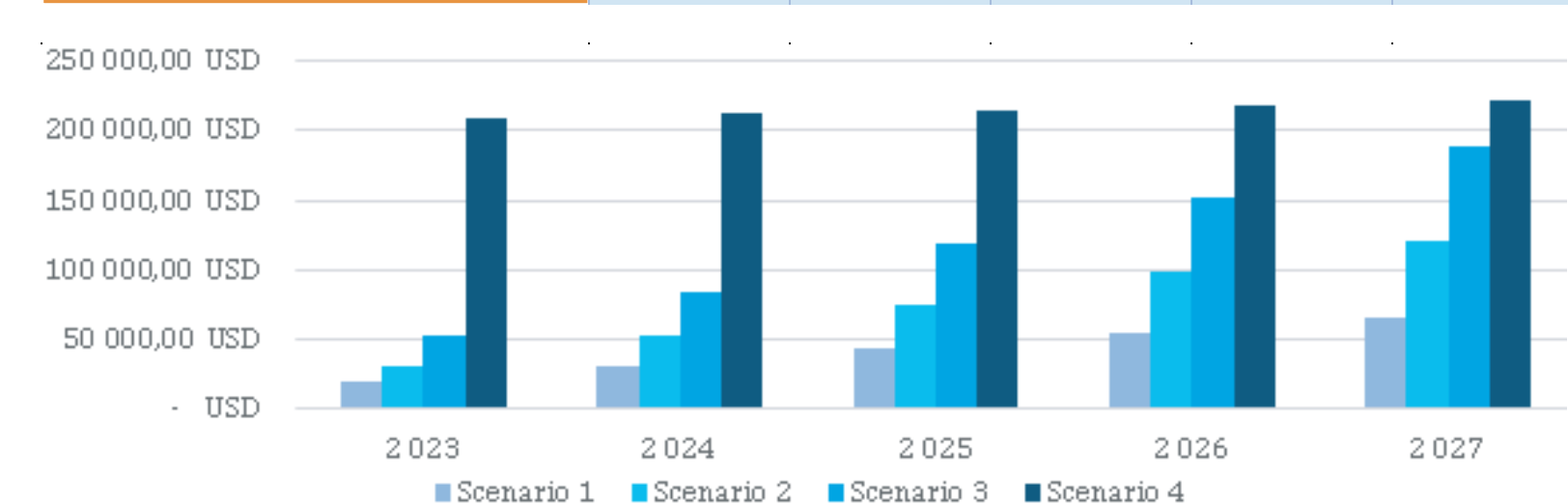


Fig 4- Cost saving of using AI-based screening program.

DISCUSSION AND INTERPRETATION

The total cost of DR is estimated at 25.5 MUSDD in 2023, with an average total cost of 35 USD per patient per year. These findings provide a precise assessment of the economic burden imposed by DR on the Algerian health care system.

Modeling over 5 years, the implementation of an early detection program for DR in Algeria allowed to identify and treat patients earlier, leading to a significant reduction in the number of people suffering from this disease. This proactive approach resulted in a 42% reduction in costs associated with the management of this complication. The results highlight the importance of investing in early detection programs, to improve clinical outcomes and to achieve substantial savings.

The in-depth study reveals promising results in terms of cost reduction compared to conventional methods. The automated eye examination costs 5,42 USD, a significant saving which is three times less expensive compared to the conventional method that costs 14,58 USD per patient. This price difference shows the financial advantage of the automatic approach. Depending on the scenarios, a reduction of 6% from the first year and up to 19% by 2027 is envisaged. In the case of a complete transition, a substantial saving of 63% is expected. In addition to the savings generated by using these AI-based methods, it was possible to speed up the screening process by taking less time and reaching a larger patients with diabetes, allowing for faster detection of positive cases and an appropriate early intervention.

CONCLUSION

DR represents a significant economic burden that requires appropriate measures to prevent its continued increase. Early detection appears to be a promising solution to reduce this economic burden by enabling early detection of the disease signs. Recent advances in AI allowed the development of new automated methods that overcome the limitations associated with analyzing images of the eye during the screening process.

These AI-based automatic methods, have demonstrated their ability to enhance early detection and timely treatment of DR while reducing healthcare costs. They offer an accurate and reliable solution to identify patients at risk, allowing for early intervention and appropriate monitoring. Therefore, these new automatic methods contribute to reduce the economic burden linked to DR by optimizing the use of available resources.

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Abbreviations :

DR: Diabetic retinopathy.
DME: Diabetic Macular Edema.
AI: Artificial intelligence.
SADIAB: Algerian Society of Diabetology.
USD: US dollars.
NPDR : Non-proliferative diabetic retinopathy.
PDR : Proliferative diabetic retinopathy.
MUSD : Million US dollars

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