Supporting Material is available for this work. For more information, follow the link from the Table of Contents to "Accessing Supporting Material".

# Implications in the health sector given the tendency of population aging in Mexico.

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*Abstract*

During century XX, the health systems have evolved to exaggerated steps. The technology advances every day, and this takes to an improvement in the people's quality of life a thus, in the increase in life expectancy.
The increase in the life expectancy of the Mexicans will make that the future generations will be, in average, older than they were during the last century since the greater adult population duplicates every 19 years. One of the implications of this is a considerable increase in the demand of public services of health. The number of pensioners will be greater than the productive population, which implies that the budget for the health sector will be insufficient, and this will gradually take it to the collapse of public health systems.
This paper is about a model that captures the changes in the Mexican population pyramid and the repercussions in the public health systems. The investigation is focused on the main organisms of public health sector, the budget that they receive from government and the expenses that pensioner represents to them during the next 25 years.
Using the model we have found that these changes in the population have serious implications that impact the future generations of pensioners and the services of which they are beneficiaries.

## II. Description of the problem.

At present day, México faces a transition in its demographic structure, which is reflected in a gradual process of narrowing in the base of the population pyramid and the widening in its top caused by diverse factors, such as the deacrese of the births rate and the increase in the life expectancy due to medical advances. This events lead to a diminish in the proportion of children and young people and a increase in the adult population.

The population growth has initiated its stabilization and the reality is that in the future there will be less children than in the past. An INEGI estimation suggest that in the next 20 years, The people over 65 years will about 15 million, 6 million more than now; this means that in 2002 one of each 10 Mexicans is greater of 60 years, but in 2051 one of each four he will be greater of 60 years.

The origin of the change in the population pyramid is reflected between 1970 and 2000, in where the population of minors of 15 years of age increased of 22 to 33 million people and the population of 15 to 64 years increased of 24 to 59 million; in that way the population under 15 years diminished from 46% to 34% of the total population and the segment between 15 and 64 years increased from 50% to 61%. An estimation suggest[1] that the group of 15 to 64 years will continue increasing of 59 million in 2000 to 75 million in 2010 and to 87 million in 2030. This tendency can be observed in Fig. 1 and 2.

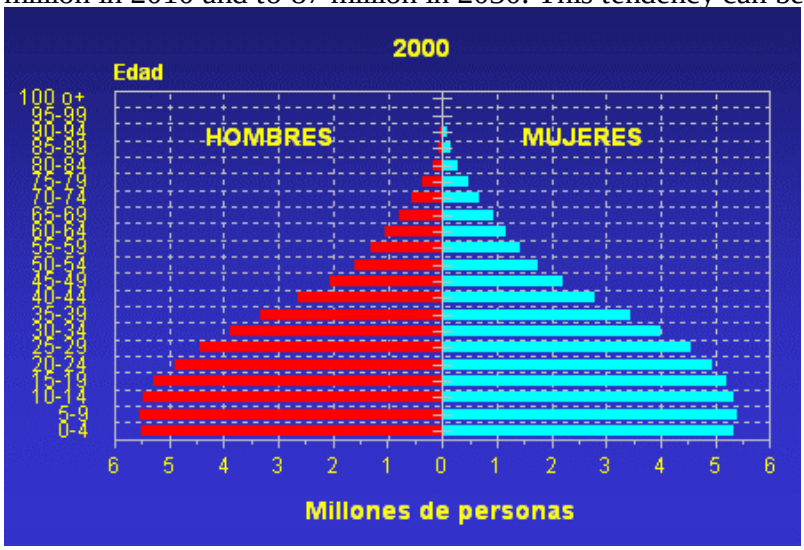


**Fig. 1 Population pyramid of the year 2000**

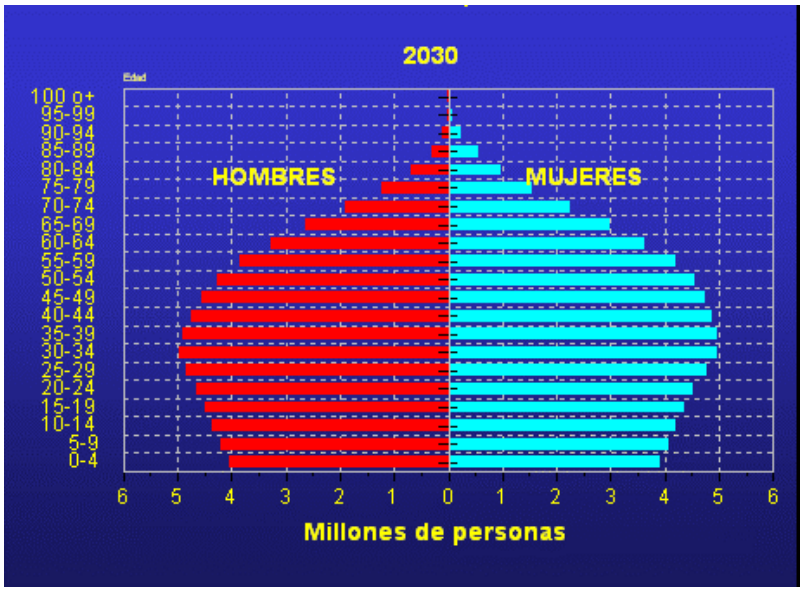


**Fig. 2 Estimate population pyramid of the year 2003**

About life expectancy, in Mexico it has been reached levels observed in the developed countries. In 1995 the life expectancy for men was of 70 years and for women of 76

[1] Hernández Bringas, Héctor. La población de México al final del siglo XX. V Reunión Nacional de Investigación Demográfica. 1996

years, nevertheless differences of the levels between the different regions from the country persist, being the most developed regions favored. This tendency is shown in Fig. 3.

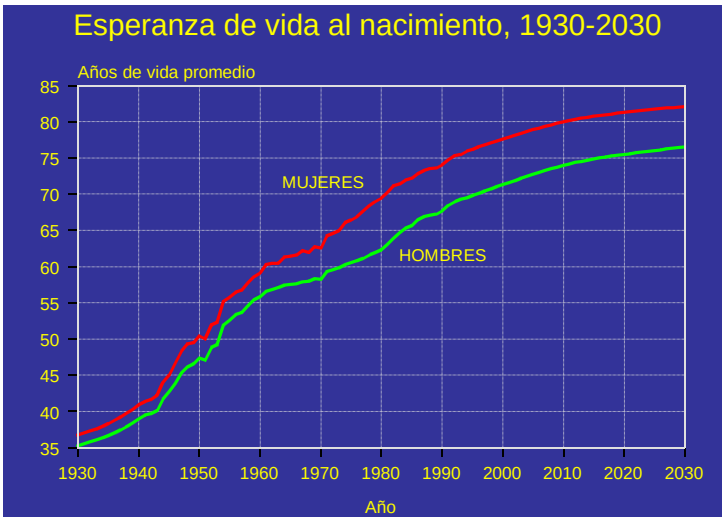


**Fig. 3 Life expectancy tendency.**

Although the differences of the life expectancy between the regions are small (four years at the most), demographically these differences are important because the population pyramid distribution and his relation with the people who will need a pension an health services a few years more. According to the CONAPO[2], the life expectancy it has increased from 35 years in 1930 to 75 years at the present time and continues increasing.

By the other side, the decrease in the birth rate was affected by the practices of birth control, supported on government programs that suggest the diminution of the number of children by woman after reaching his historical maximum level of 7.3 children average by woman in the Sixties. At the present time the average number is 2.4 children. The tendency is shown in Fig. 4.

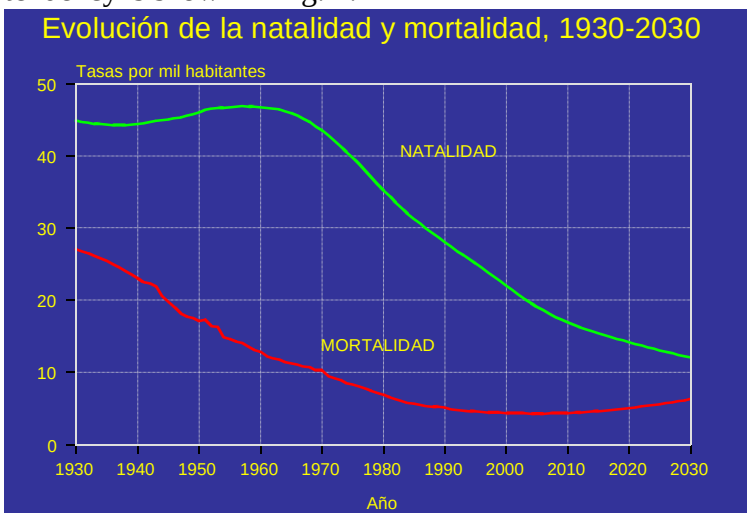


**Fig. 4 Birth and death rates.**

[2] Population Nacional Council

Based on this data, the projection is that the population over 65 years will grow from 1.8 million people in 1970 to 4,8 million in 2000 and to 27,3 million in the 2050 as shows in Fig. 5. This bring also an increase in the economically active population. At present, it is about 43 million workers, and it will ascend to almost 55 million in 2010 and 69 million in 2030. But also this phenomenon will bring future social and health problems.


**Fig. 5 People over to 65 years tendency.**

One of the most worrisome risks of the inevitable demographic aging is that this phenomenon is accompanied of another one, related to the impoverishment of the senior people. This risk is associated to the drastic reduction of the labor opportunities to which the seniors have access outpost, to the gradual lost of their physical capacities and health, to the insufficient support of the social security systems and to its greater economical dependency of their relatives, whose amounts, generally, are bare and irregular.

Although the PEA (economically active population) will keep increasing, it will reach their maximum level in 2040, according to data of the CONAPO, almost the double that 45 years before. But in that year the PEA will begin to have a reduction due to the gradual aging of the population, and the group of working people will tend more and more to concentrate between the adults and the seniors and it will not allow to compensate in the long term the youngest people decrease.

On the other hand, the health sector also would be affected by this increase in the life expectancy since, according to statistics, Mexican elder population constitute at the present time the 7.2 percent of the total population and tendency point out that in 2050 they will represent the 27 percent. This situation have a hugh impact in the main health public instittutions: IMSS and ISSSTE [3], whose at the present time suffer an economic

[3] IMSS (Social Security Mexican Institute) offers health services to working people. The companies who hire people have the obligation to subscribe them and pay a monthly fee.
ISSSTE affiliate the government employees such as public education teachers.

crisis, which causes that they do not have sufficient medicines to attend total demand. For example, the patiens who suffers chronic diseases, like diabetes or hypertension consume the 25 percent of the resources of the IMSS, although they represent only the 2 percent of the total, and a 50 percent goes to retired people pensions.

For that reason, it is necessary to consider these elements in terms of policy design impact considering medium and long term so that the efforts that will make benefit the more vulnerable population groups, in which difficult life conditions prevail.

## III. objective of the model

The objective of the model is to analyze the implications that an increase in life expectancy in Mexico will have in public health institutions such as IMSS or ISSSTE in a 2050 time horizont . At present time these institutions are in economic crisis so an increase in life expectancy would make them worst.

## IV. Hypothesis

In next years, public health institutions will not have the capacity to maintain the growth of the pensioned population since the cost of this will be over the budget that annually the government destines to the health sector.

## V. Assumptions behind the model.

In this system, given the characteristics of the input data (which were very dificult to obtain since public information is not fully available) we only have a balancing loop in wich it can be observed that the dynamics of the capacity of the IMSS-ISSSTE is limited by the pensioned amount of PAM (greater adult population) so more pensioned PAM it has, greater will be the demand towards IMSS-ISSSTE and less will be their capacity.

On the other hand, less capacity of the IMSS-ISSSTE settles down more age to pension itself, which causes a diminution of the pensioned amount of PAM and with it the cost is balanced and a balance between the demand looks for towards the IMSS-ISSSTE and their capacity.

The troubles in this system initiates in the Greater Adult Population stock, which projects the amount of total adult people in a time horizont The increase in this level is determined by the amount of people over 65 years (this segment is called the third age).

As well, the amount of PAM determines the amount of adults greater than those have insurance and those who have not; having a proportional relation since a percentage of this population destines at the level of PAM assured and another not assured percentage at the level.

These two new levels, whose input streams are determined by the main level (PAM), diminish their value to the being affected by the variable deaths of the PAM; which keeps logic since as well as they are increased by the increase of the adult population, also its value diminishes when this one population dies.

On the other hand, when already having the total of assured and assured greater adults two new levels are not created to determine the impact that they have in the different systems from health. In the case of the assured population, the amount of affiliated adults directly affects at the new called level Capacity of the IMSS-ISSSTE since between more assuring, it is more the cost to which they incur since each person represents a cost of $3.000 pesos.

In the case of the assured population, this one also demand services but to the SSA but in this block does not count on a loop examiner of accounts since the SSA does not have way to regulate the PAM entrance.

Finally it is identified that the point of leverage of the loop is the age to pension itself since between greater is this age, minor PAM will demand services of health and the institutions will be able to have greater capacity.

## IX. Simulation

Using the Ithink simulator a model was designed( Fig 6.) The equations are included in apendix 2.

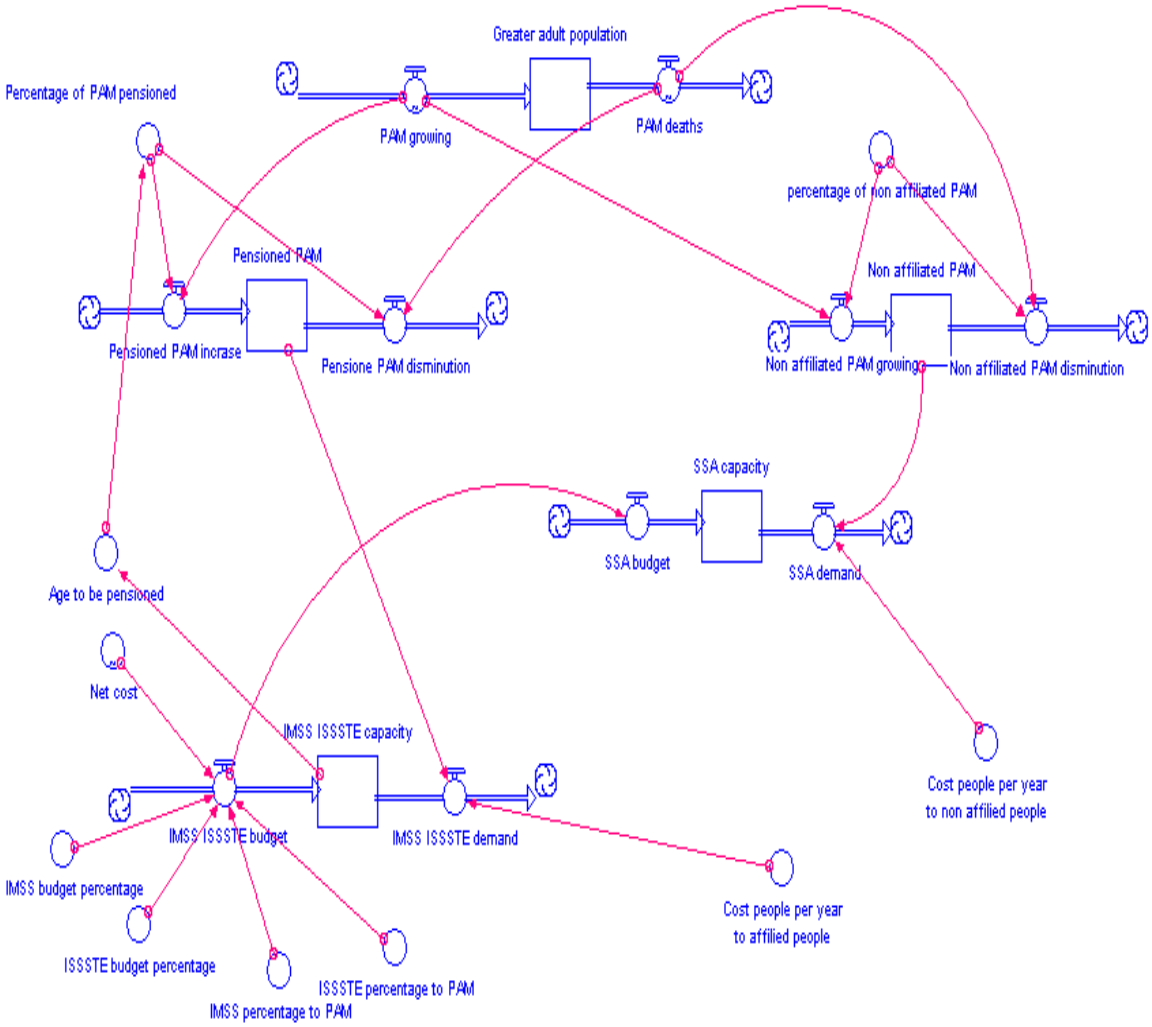


**Fig 6. Simulation model.**

## X. Results of the simulation.

Firstly it was decided to observe the tendency of the greater adult population. One ran the simulation generating graphical and tables that are included in annexed the 2 and whose results are described next. With respect to the PAM it is observed in the fig. 7 that this one will grow of considerable way during next the 20 years. At the moment (year 2000), it has around 6,8 million adult people, but in 2020 this one will be increased until around 14,3 million people, a quite great increase, that the main problem of the systems of health and pensions.

PENSIONED PAM

Therefore, as a result of the increase of the PAM, the number of pensioners also will grow in the same proportion (fig 3) since being around 3,15 million pensioned greater adults, in the 2020 they will be approximately 6,5 million pensioners.

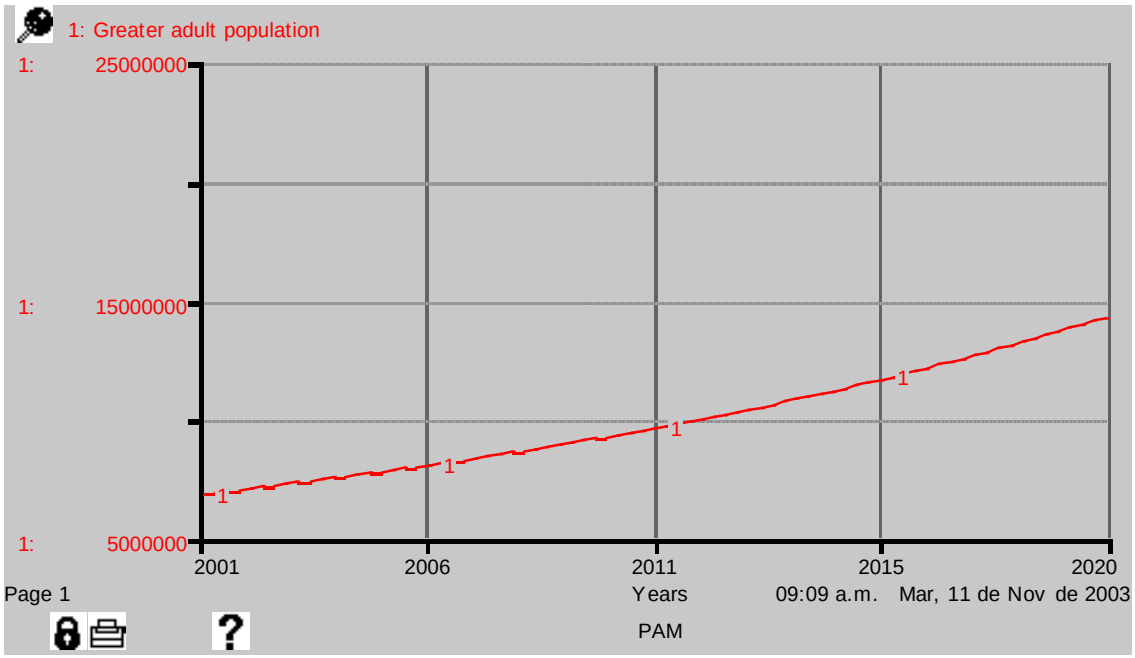


**Fig. 7. Greater adult population.**

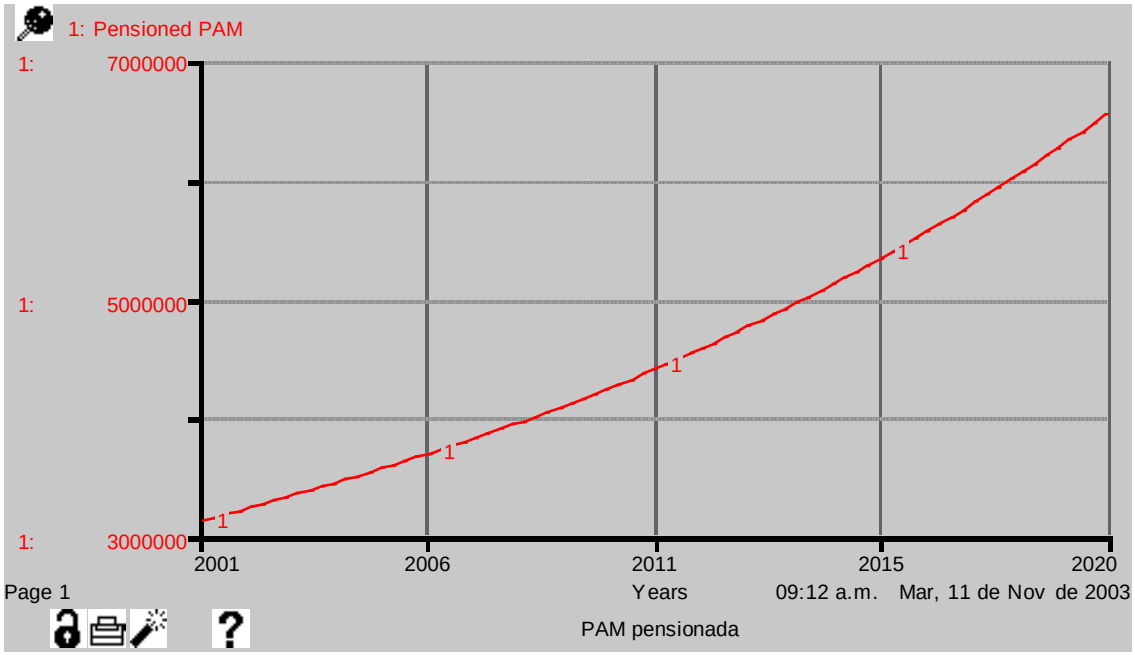


**Fig. 8. Pensioned population.**

PAM NON AFFILIATED

Another subsystem important to observe is the PAM nonpensioned or not affiliated with any Institution, that of the same form that the pensioned PAM, will be increasing, which

also puts in jams to the SSA (Fig. 8), that at the moment takes care of around 3,65 million people, but in the 2020 it will have to be able to take care of 7,7 million people.

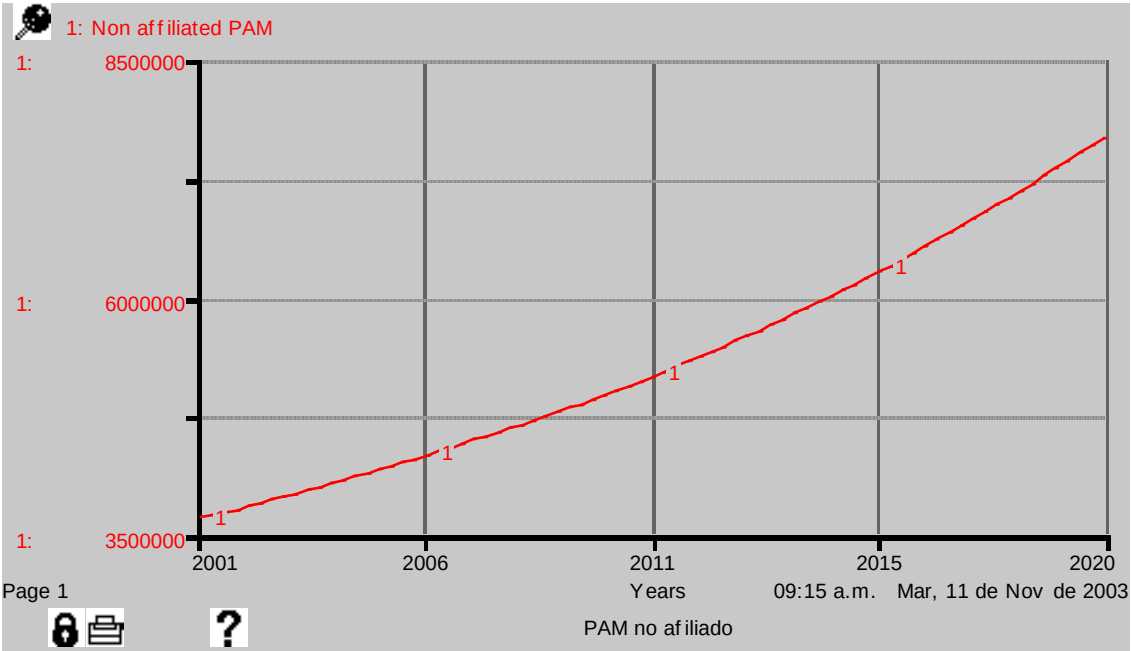


**Fig 9. Non affiliated population.**

CAPACITY IMSS ISSSTE

Due to the growth of the mentioned PAM previously, the monetary capacity of the Institutions of Health (IMSS, ISSSTE) to be able to take care of this population is diminished during next the 20 years (Fig. 9), until arriving at red numbers in approximately 10 years. It is necessary to mention that this is without taking into account the debt that has these Institutions at the moment. This is very worrisome since at the moment these Institutions have affiliated around 3 million adult people, counting on a budget of 100 billion weights, if the cost by person is of around 3000 pesos, reason why has a mattress of 90 billion weights for unforeseen expenses. But in 2011, as it is observed in the following Table, it would have to let take care of around a million people to support the debt that will be increased through the years.

| Years | capacidad IMSS ISSSTE |
|---|---|
| Initial | $1.097039e+011 |
| 2001 | $1.011631e+011 |
| 2002 | $9.232188e+010 |
| 2003 | $8.316790e+010 |
| 2004 | $7.368724e+010 |
| 2005 | $6.386483e+010 |
| 2006 | $5.368591e+010 |
| 2007 | $4.313420e+010 |
| 2008 | $3.219055e+010 |

| | |
|---|---|
| 2009 | $2.082865e+010 |
| 2010 | $9,019,509,139.068913 |
| 2011 | -$3,266,047,572.082127 |
| 2012 | -$1.605510e+010 |
| 2013 | -$2.937652e+010 |
| 2014 | -$4.326273e+010 |
| 2015 | -$5.775083e+010 |
| 2016 | -$7.287719e+010 |
| 2017 | -$8.867698e+010 |
| 2018 | -$1.051850e+011 |
| 2019 | -$1.224346e+011 |

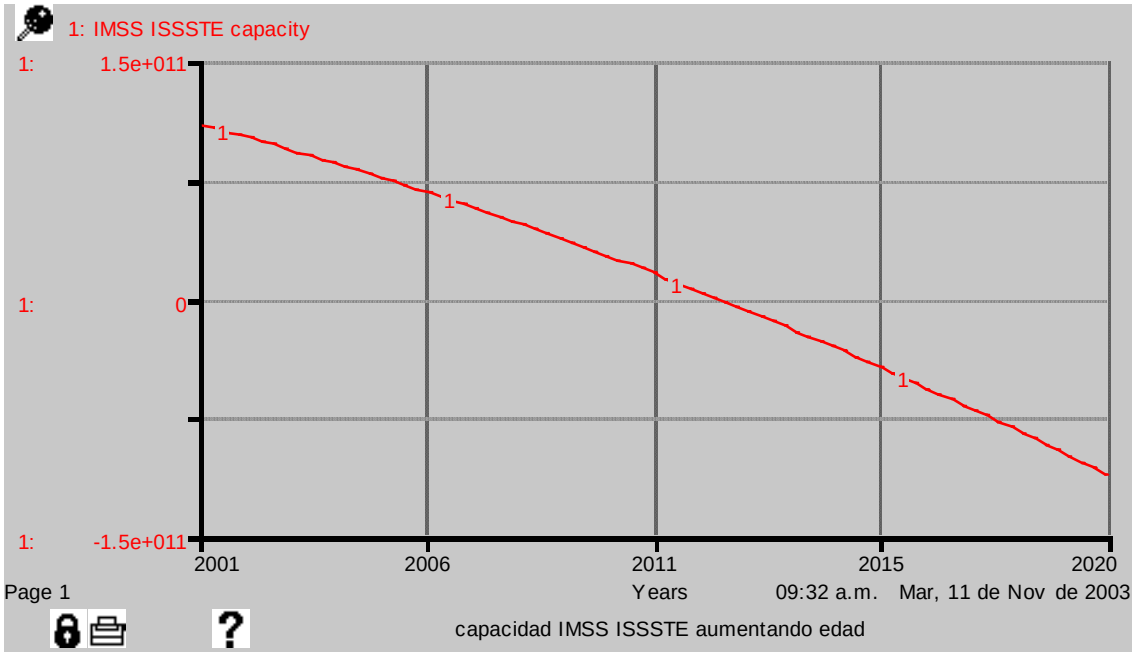


**Fig 10. Economic capacity of IMSS and ISSSTE.**

The same problem will have the SSA. As it is appraised, the monetary capacity of this Institution (fig 6) has the same behavior observed in Fig 10. Like the IMSS and the ISSSTE, the SSA will have red numbers in approximately 10 years. Reason why in 2010 it will have to let take care of around 2.5 million of greater adult person not affiliated to resolve his debt, that also will be continued increasing years with year.

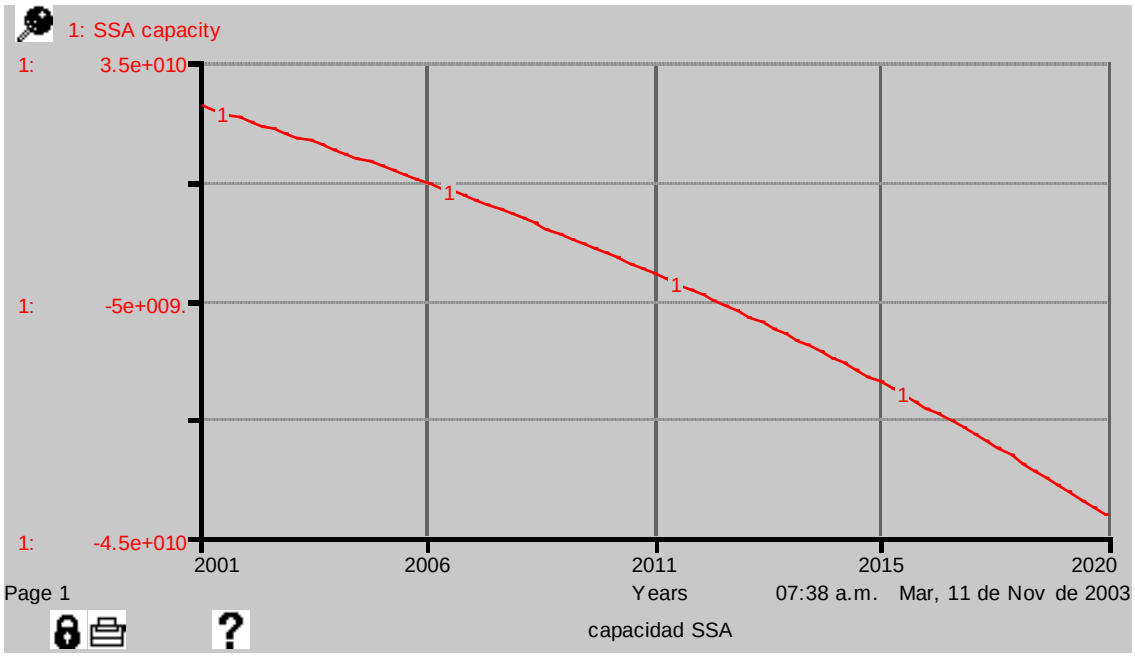


**Fig 11. Economic capacity of SSA.**

INCREASING THE AGE

Perhaps the improvement in the system is not appraised very well but we can see that the debt diminishes (Fig. 11), and perhaps in later years it is managed to balance the number of people to take care of with the capacity of the Institutions. In year 2020 it is appraised that maintaining the age of 60 years to pension itself, the debt is of 122 billion weights, and increasing to the age to 70 years this is reduced to 112 billion weights.

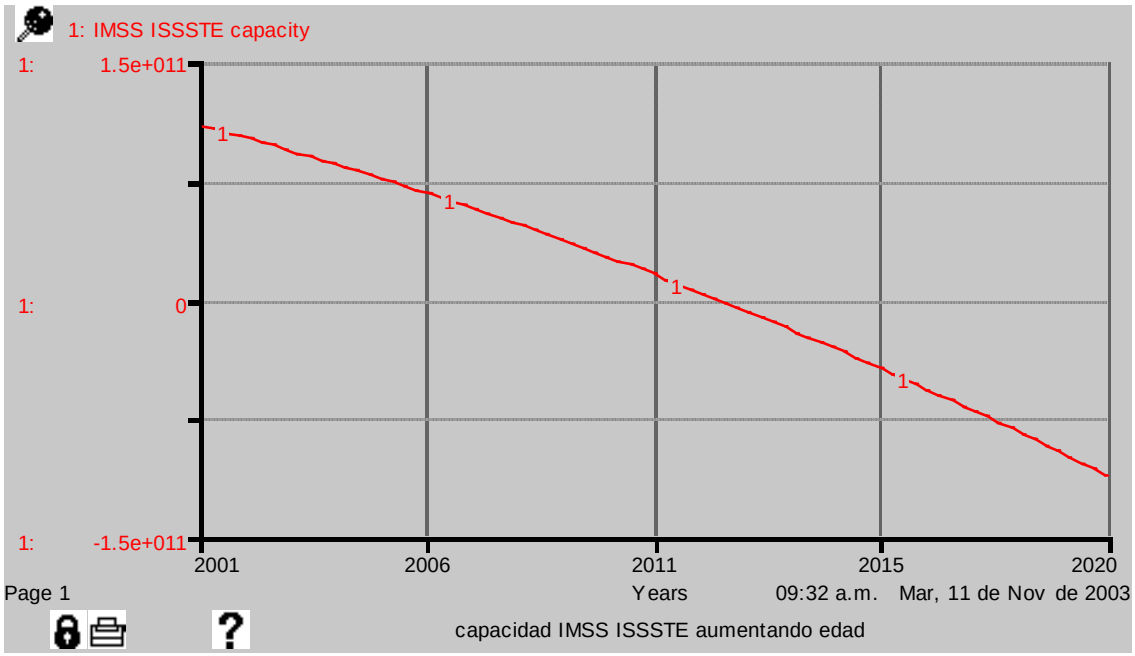


**Fig 12. economic capacity of health instutions increasind the age.**

## XIV. Conclusion.

When making the bullfight of the model, we could confirm the hypothesis raised at the beginning of the project, since we observed the incapacity of the Institutions of health and pensions to be able to support the increase in the PAM. Given the previous thing, the alternatives of solution for the problem can come to increase the age to pension themselves in the workers of the same institutions of health. At the moment the negotiations are being carried out to modify the retirement regulations but they have not been accepted. Nobody wants to sacrifice the benefit in the short term by the subsistence of the institutions. In other words, they are inheriting a pump of time to the generations of next the 20 years.

## XV. References.


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Apendix 1.**Dictionary of variables**

The next table contains the specification of the main variables of the model.

| VARIABLE | UNITS | DESCRIPTION |
|---|---|---|
| Incrase pensioned PAM | Persons/year | It is the amount of people per year who integrate themselves to the pensioned PAM |
| Capacity IMSS ISSSTE | Money (Mexican pesos) /year | It is the amount of money that these institutions must to take care of the pensioners of the PAM per year<br>Bottom of Form |
| Capacity SSA | Pesos | Is the amount of money whereupon it counts the SSA to take care of the PAM in that year<br>Bottom of Form |
| Cost per person per year for affilieated persons | Money (Mexican Pesos)/year | Is the cost by annual person of the PAM to be taken care of in the IMSS-ISSSTE<br>Bottom of Form |
| Cost per persons per year for non affiliated persons | Money (Mexican Pesos)/year | It is the cost by annual person of the PAM to be taken care of in the SSA<br>Bottom of Form |
| Increase PAM | Persons | Growth of the greater adult population<br>Bottom of Form |
| Increase PAM non affiliated | Persons | Growth of the adult population greater than not this affiliated with the IMSS-ISSSTE<br>Bottom of Form |
| Demand to IMSS-ISSSTE | Money (Mexican Pesos) /ayear | It is the cost of the pensioned PAM to be taken care of in that year<br>Bottom of Form |

| | | |
|---|---|---|
| Demand to SSA | Money (Mexican Pesos)/year | Is the cost of the affiliated PAM not to be taken care of per year.<br>Bottom of Form |
| Decrease PAM non affiliated | Persons | PAM nonaffiliated that dies in a year.<br>Bottom of Form |
| Decrase pensioned PAM | Persons | Affiliated PAM that dies in a year.<br>Bottom of Form |
| Age of pension itself | Years | It is the age that marks the law so that the insurance begins to pay pensions<br>Bottom of Form |
| Net cost | Money (Mexican Pesos) | Budgetary cost of the government per year.<br>Bottom of Form |
| Deaths PAM | Persons | It is the number of people who die per year depending on the rate of deaths.<br>Bottom of Form |
| PAM | Persons | Greater adult population, whose rank of age goes ahead of 60 years in depending on the life expectancy in that year.<br>Bottom of Form |
| PAM non affiliated | Persons/years | It is the amount of people per year who are no affiliated |
| Pensioned PAM | Persons/years | It is the amount of people per year who are pensioners<br>Bottom of Form |
| Percentage of PAM non affiliated | Percentage | Is the percentage of the PAM that is not pensioner per year<br>Bottom of Form |
| Percentage of IMSS for PAM | Percentage | Percentage of the budget of the IMSS destined to the PAM |

| | | |
|---|---|---|
| | | Bottom of Form |
| Percentage ISSSTE for PAM | Percentage | Percentage of the budget of the ISSSTE destined to the PAM.<br>Bottom of Form |
| Percentage PAM pensioned | Percentage | It is the percentage of the PAM that is pensioner per year<br>Bottom of Form |
| Budgeted percentage IMSS | Percentage | Percentage of the public cost destined to the IMSS<br>Bottom of Form |
| Percentage of Budget ISSSTE | Percentage | Percentage of the public cost destined to the ISSSTE<br>Bottom of Form |
| budget al SSA | Money (Mexican Pesos) | It is the budgeted amount that the government destines for the expenses of the SSA.<br>Bottom of Form |
| Budget IMSS-ISSSTE | Money (Mexican Pesos) | It is the budgeted amount that the government destines for the expenses of IMSS and ISSSTE.<br>Bottom of Form |

**Apendix 2**

Equation and brief description.

**INIT capacidad_IMSS_ISSSTE = 109703923300**
This number we calculated it based on the Federal Budgetary Cost destined to the IMSS and ISSSTe and later to this amount we calculated the corresponding amount to him that these institutions destine to the PAM.

**presup_IMSS_e_ISSSTE= gasto_neto*porc_presup_IMSS*porc_IMSS_para_PAM) + (gasto_neto*porc_presup_ISSSTE*porc_ISSSTE_PAM)**
This budget was calculated in base to the found percentage that the Federal Government destines del public cost later al IMSS and ISSSTE and with the calculated percentage that IMSS and ISSSTE destine to the PAM. They are multiplied since first a percentage removes to him to the net cost and from that same amount another percentage removes.

**Demanda_al_IMSS_ISSSTE** =
PAM_pensionada*costo_personas_por_año_para_pers_afiliadas
capacidad_SSA(t) = capacidad_SSA(t - dt) + (presupuesto_al_SSA - demanda_al_SSA) * dt
INIT capacidad_SSA = 27425980830

**presupuesto_al_SSA = presup_IMSS_e_ISSSTE/4**
This equation on the basis of a data was defined that we found in the Secretariat of Health that mentioned that by each 4 (Mexican money) that were destined to IMSS and ISSSTE 1 peso was destined to the SSA. So we supposed that the budget for the SSA is a quarter of the budget of the IMSS-ISSSTE.

**demanda_al_SSA** =
**PAM_no_afiliado*costo_personas_por_año_para_pers_no_afiliadas**
This demand we had it to turn to weights so we looked for how much money cost to the IMSS to maintain a person to him adult and with that data we multiplied it by the amount of PAM.

**INIT PAM_no_afiliado = .54*6752115**
This number we calculated with the percentage of PAM nonaffiliated and the initial value of the PAM removed from a file of the Secretariat of Health where the total population per years offers divided by ages.

**crecimiento_PAM_no_afiliado** =
**crecimiento_PAM*porcentaje_de_PAM_no_afiliada**
This data also this on the basis of the same file mentioned previously of which we calculated the growth per year of the PAM and to turn it to the value of the PAM nonaffiliated we multiplied it by the percentage of which not this affiliated with the IMSS-ISSSTE.

**disminucion_PAM_no_afiliado = muertes_PAM*porcentaje_de_PAM_no_afiliada**
Since we found the total of the deaths per year divided by age, we calculated the deaths of the PAM per year and on the basis of that data we removed the corresponding percentage to him from the PAM nonaffiliated and thus we obtained the diminution of the PAM nonaffiliated.

**INIT PAM_pensionada = .46*6752115**
This initial value we calculated it helped of the percentage that we found corresponding to the pensioned PAM and when multiplying it by the initial value of the PAM it offers the value us of the pensioned PAM.

**aumento_de_PAM_pensionada = crecimiento_PAM*porc_de_PAM_pensionado**
This equation of flow we calculated it after calculating the change in the total of adult population per year and to this one number we multiplied it by the percentage of the pensioned PAM and thus we managed to only calculate the increase of the pensioned PAM.

**Dism_PAM_pensionada = muertes_PAM*porc_de_PAM_pensionado**
In this equation we became to base on the file of deaths and for every year we calculated the pensioned percentage of PAM that dies by means of the multiplication of the total of the deaths of PAM by the percentage of the pensioned PAM.

**INIT poblacion_adulta_mayor = 6752115**
This number was a direct data that we found in the file of the total population per years. What we did was to add the total of population of 60 years in in front of men and women.

**crecimiento_PAM = GRAPH(TIME)**
**(2001, 490619), (2002, 506338), (2003, 523216), (2004, 541743), (2005, 561541), (2006, 580805), (2007, 602707), (2008, 626601), (2009, 658688), (2010, 690717), (2011, 724202), (2012, 755084), (2013, 790110), (2014, 827740), (2015, 870909), (2016, 911484), (2017, 953082), (2018, 995030), (2019, 1e+006), (2020, 1.1e+006), (2021, 1.1e+006), (2022, 1.1e+006), (2023, 1.2e+006), (2024, 1.2e+006), (2025, 1.3e+006), (2026, 1.3e+006), (2027, 1.3e+006), (2028, 1.4e+006), (2029, 1.4e+006), (2030, 1.4e+006), (2031, 1.5e+006), (2032, 1.5e+006), (2033, 1.5e+006), (2034, 1.5e+006), (2035, 1.6e+006**

Given to the characteristics of the data the population, which come from a table in Excel, we calculated the increase of the adult population per year and thus we fed the graph that defines the growth of the PAM.

**muertes_PAM = GRAPH(TIME)**
**(2001, 253394), (2002, 259618), (2003, 266212), (2004, 273186), (2005, 280542), (2006, 288299), (2007, 296502), (2008, 305197), (2009, 314444), (2010, 324230), (2011, 334569), (2012, 345467), (2013, 356951), (2014, 369064), (2015, 381830), (2016,**

**395239), (2017, 409298), (2018, 424016), (2019, 439384), (2020, 455398), (2021, 472050), (2022, 489331), (2023, 507271), (2024, 525877), (2025, 545171), (2026, 569170), (2027, 585870), (2028, 607280), (2029, 629381), (2030, 652196), (2031, 675761), (2032, 700063), (2033, 725071), (2034, 750755), (2035, 777084)**

In order to calculate the deaths of the PAM also we counted on direct data so we only fed the graph with the deaths corresponding to the PAM for every year.

**costo_personas_por_año_para_pers_afiliadas = 3000**
We found it in the Secretariat of Health.

**costo_personas_por_año_para_pers_no_afiliadas = 750**
In order to calculate this data we returned to use the assumption that the resources of the SSA are ¼ of those of the IMSS-ISSSTE, so again we supposed that for the SSA the cost by taken care of person is a quarter of which it represents for the IMSS-ISSSTE.

**porcentaje_de_PAM_no_afiliada = .54**
This data was calculated on the basis of data projected by the Secretariat of Health, in which it calculates east percentage for years 2000 to the 2005. From these data we removed an average and we concluded that approximately he is 54% of the PAM that not this affiliated.

**porc_de_PAM_pensionado = .46**
Like the last percentage, this one, we calculated it in the same way of the same source

**porc_IMSS_para_PAM = .1113**
This percentage was calculated on the basis of a file where we found the distribution of the cost of the IMSS; in which we observed, for two years different, the relation between the total cost and the cost destined to the PAM corresponded approximately to the 11.13%.

**porc_ISSSTE_PAM = .1113**
In the case of the ISSSTE, in view of which we did not find a document similar to the one of the IMSS we supposed that the relation is the same one since both they are health centers and the criterion to destine the cost to the PAM had to be similar.

**porc_presup_IMSS = .152**
This percentage the calulamos on the basis of the archives of the federal net cost destined to the IMSS in 2001, 2002 and 2003. Of we calculated the relation between the total of the net cost and the percentage there that the cost represents destined the IMSS.

**porc_presup_ISSSTE = .047**
This percentage was calculated in the same way that the one of the IMSS, single that with the data corresponding to the cost destined to the ISSSTE in those same years.

**gasto_neto = GRAPH(TIME)**

**(2001, 4e+010), (2002, 4.2e+010), (2003, 4.3e+010), (2004, 4.5e+010), (2005, 4.7e+010), (2006, 4.9e+010), (2007, 5.1e+010), (2008, 5.3e+010), (2009, 5.5e+010), (2010, 5.7e+010), (2011, 6e+010), (2012, 6.2e+010), (2013, 6.5e+010), (2014, 6.8e+010), (2015, 7e+010), (2016, 7.3e+010), (2017, 7.6e+010), (2018, 7.9e+010), (2019, 8.3e+010), (2020, 8.6e+010), (2021, 8.9e+010), (2022, 9.3e+010), (2023, 9.7e+010), (2024, 1e+011), (2025, 1.1e+011), (2026, 1.1e+011), (2027, 1.1e+011), (2028, 1.2e+011), (2029, 1.2e+011), (2030, 1.3e+011), (2031, 1.3e+011), (2032, 1.4e+011), (2033, 1.4e+011), (2034, 1.5e+011), (2035, 1.6e+011)**

Since the net cost of the federation is a direct data which we found in the single Secretariat of Economy but for later years, on the basis of them calculated a rate of growth and projected for future years and with those data we fed the graph that represents this variable to us.

**edad_para_pensionarse =**
**IF(capacidad_IMSS_ISSSTE<20000000000)THEN(70)ELSE(60)**
The previous equation was made to try to solve the problem of IMSS and ISSSTE, for which which assumed that the legislation of pensions it would change to increase the age to pension itself of 60 to 70 years, would reduce the number of pensioners and could have an improvement in the system.

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