# Economic burden of Chronic Kidney Disease (CKD) in Type 2 Diabetes (T2D), considering the costs of cardiovascular hospitalization events in Colombia.

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## Introduction

Around 25% to 40% of patients with type 1 or type 2 diabetes (T2D) will develop Chronic Kidney Disease (CKD) at some point in their disease [1].
The incidence of CKD has doubled in the last decade, primarily due to the increase in T2D, with diabetic kidney disease (DKD) being the cause in 45% of new cases of end-stage renal disease in the United States, while hypertension and glomerular diseases rank second and third, respectively [1, 2].
In Colombia, the High-Cost Account estimates the prevalence of diabetes to be over 1.99 million people [3].

CKD in T2D is the most common microvascular complication in diabetic patients, occurring in up to 40% of cases [4]. The importance of analyzing this condition and evaluating its costs for the healthcare system is highlighted by the fact that between 2022 and 2023, new cases (incidence) of patients with stage 5 CKD increased by 177% [3]

T2D is also an important risk factor for cardiovascular disease (CVD), but CKD is an important mediator of this risk. Multiple CVD outcomes trials have shown a greater risk for CVD events in patients with diabetes with CKD versus those without renal compromise. [5]
The hazard ratios (HR) for acute myocardial infarction, stroke, heart failure, and cardiovascular hospitalization according to levels of albuminuria/creatinine ratio (ACR) and estimated glomerular filtration rate (eGFR) were taken from the international guidelines KDIGO 2024 [6]

### Figure 1. HR for cardiovascular evento according to ACR and eGFR



## Objective

To estimate the economic burden of Chronic Kidney Disease (CKD) in Type 2 Diabetes (T2D), considering the standard of care and the costs of cardiovascular events in Colombia.
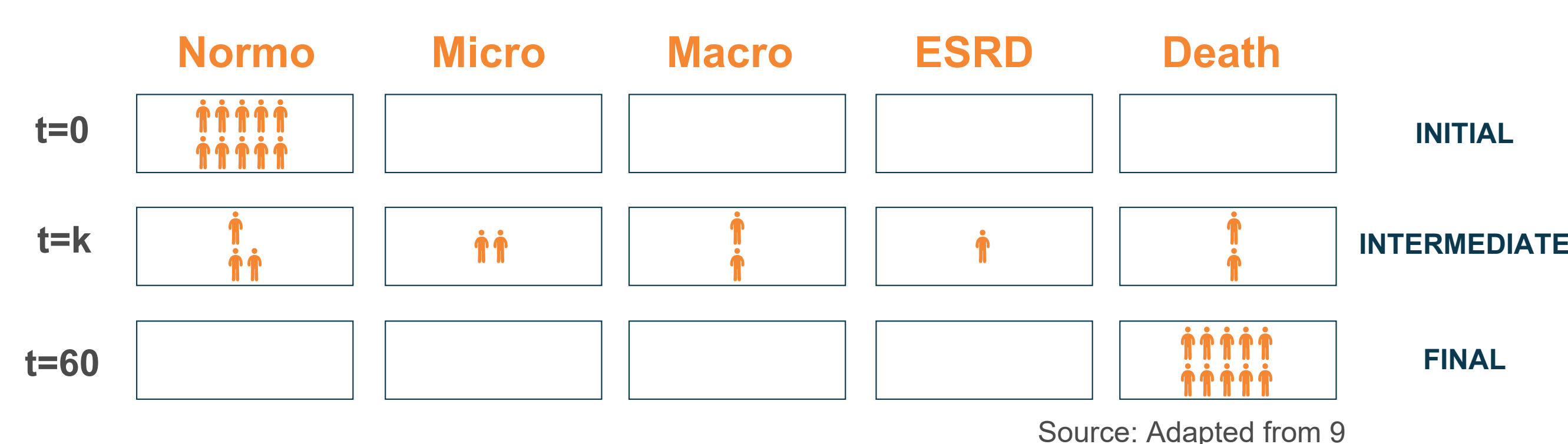
## Methods & Results

The cost analysis presented here was conducted from a social perspective, focusing primarily on the Health System of Colombia applying a macro-costing strategy and a top-down approach (7).
For direct costs of CKD and T2D estimated using Gestion de la Demanda of SISPRO database (8). Initially, the Codigo Unico de Procedimiento (CUP) codes were determined which, except for dialysis care and kidney transplantation, represented many of healthcare costs of ICD-10 codes N17-N19. As a second step, for the ICD-10 codes associated with End Stage Renal Disease (ESRD) (E102, E112, E142, N06X, N083, R80X), the average cost of the selected procedures was determined along with the cost of medications and supplies for affiliates of the contributory regime who had at least one healthcare service. For the advanced stage - replacement therapy - the previously calculated average value was added to the estimated average cost of dialysis for the treated affiliates, according to the same information.

The hospitalization costs for CVD events were selected with the main diagnosis being the ICD-10 codes associated with acute myocardial infarction, infarction and heart failure, and the costs were segmented considering only the hospitalization care setting. The hospitalization costs for cardiovascular events were adjusted to 2024 prices (Table 1).

### Table 1. Cost of each cardiovascular event were:

| The cost of each cardiovascular events were: | |
| --- | --- |
| **Outcome** | **Patient/costs Year (USD$)** Using an exchange rate of COP$4.061 Colombian pesos per US dollar (USD) |
| **Stroke:** ICD: 1630 1631 1632 1633 1634 1635 1638 I639] I64 I650 I651 I660 I662 I663 G460 G462 | $ 1.904 |
| **Acute myocardial infarction:** ICD: I210 I211 I212 I213 I214 I219 I220 I221 I228 I229 I256 Z034 | $ 2.744 |
| **Heart failure:** ICD: I500 I501 I509 I420 I110 I130 I131 I132 I517 | $ 1.827 |

### Figure 2. Transition stages of CKD and T2D



Source: Adapted from 9

For a cohort of 1,000 patients, simulations are conducted that begin in normoalbuminuria and end when the entire cohort is in the absorbing state (Death – Cycle 60), estimating the costs per patient and for the entire cohort [9]
All patients start in normoalbuminuria and at the age of 40.
Life expectancy is 77.23 years (DANE, 2023).

### Figure 3. Standard Treatment Transition Matrix

| | | Normo | Micro | Macro | ESRD | Death |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | **End** | | |
| **Start** | Normo | 1-0.056-p (age) | 0.056 | 0 | 0 | p(age) |
| | Micro | 0 | 1-0.094-p(age) | 0.094 | 0 | p(age) |
| | Macro | 0 | 0 | 1-0.056-p(age) | 0.056 | p(age) |
| | ESRD | 0 | 0 | 0 | 0.87 | 0.13 |
| | Death | 0 | 0 | 0 | 0 | 1 |

Source: Adapted from 9

$$S_{placebo}(t) = \frac{N_t}{N_0}$$

The probabilities of hospitalization in the placebo group for stroke, acute myocardial infarction, and heart failure were estimated by stages using a survival function $S_{placebo}\ t$, which is the probability that an individual survives or does not experience an event (hospitalization) for a time greater than or equal to t, assuming that the person has been at risk of hospitalization (10). Using the survival function the accumulated probability $F_{placebo}\ t$ was calculated as shown below.

### Table 2. HR for cardiovascular events

| Stage | HR acute myocardial infraction | HR Stroke | HR Heart failure | HR hospitalization |
| --- | --- | --- | --- | --- |
| Microalbuminuria | 2.30 | 2.10 | 3.30 | 1.50 |
| Macroalbuminuria | 3.30 | 2.70 | 4.10 | 1.70 |
| ESRD | 5.00 | 4.40 | 7.70 | 3.00 |

Source: KDIGO, 2024

Using $F_{placebo}\ t$ and HR from Table 2. the probabilities for each cardiovascular outcome were estimated. Note that for heart failure hospitalization probabilities it is implicitly assumed that the events of heart failure and hospitalization are independent, as we have independent HR. It is acknowledged that this may not be the appropriate assumption, but it was deemed relevant given the available information.

$$Prob_{ji} = 1 - (1 - F\ (i))^{HR_{ji}}$$

$$Prob_{ji} = 1 - \frac{S(t)_{HRhosp_i \cdot nF}}{S(t)_{nF}}$$

$$Cost\ Event\ i_{\ stage\ n} = Cost\ Event\ i \cdot Prob\ evento\ i_{\ stage\ n}$$

The cost per patient/year for hospitalization due to cardiovascular events by stage of diabetic kidney disease (DKD) under current treatment was calculated using the event cost * probability of cardiovascular event occurrence

### Calculation of cumulative probabilities by stage and type of event

| Stage | Probabilitie acute myocardial infarction | Probabilitie Stroke | Probabilitie Heart failure |
| --- | --- | --- | --- |
| Microalbuminuria | 33,71% | 31,93% | 24,84% |
| Macroalbuminuria | 44,56% | 39,01% | 42,10% |
| ESDR | 59,08% | 55,33% | 94,67% |

### Patient cost/year hospitalization for cardiovascular events by ERD stage current treatment

Using an exchange rate of COP $4.064 Colombian pesos per dollar (USD)

| Stage | Microalbuminuria | Macroalbuminuria | ESDR |
| --- | --- | --- | --- |
| Acute myocardial infarction | $925 | $1.223 | $1.621 |
| Stroke | $608 | $743 | $1.053 |
| Heart failure | $454 | $769 | $1.730 |

Using an exchange rate of COP$4.061 Colombian pesos per US dollar (USD), the summary of the annual direct costs in Colombian pesos at 2024 prices, calculated based on the methodologies previously explained, is presented. These values were used to conduct the simulation with the Markov chain in each of the considered stages.

### Table 3. Patient costs/year CKD and T2D + cardiovascular outcomes with current treatment.

| Description | | Normo - albuminuria | Micro - albuminuria | Macro - albuminuria | ESRD |
| --- | --- | --- | --- | --- | --- |
| **Direct Medical Costs** | Direct costs (Renal care) | $0 | $113 | $113 | $6.300 |
| | Cardiovascular evento costs | $0 | $1.987 | $2.735 | $4.405 |
| **Out-of-pocket expenses** | Costos médicos. cuidado y transporte | $0 | $33 | $452 | $3.174 |
| **Total Direct costs** | | $0 | $2.133 | $3.300 | $13.879 |

The sources of information used to assess to the costs assumed by the household, also known as "out-of-pocket expenses" in this study were the Multipurpose Survey for Bogotá (EMB) [2], conducted by DANE in 2017, and the National Time Use Survey (ENUT), conducted by DANE during the period 2020-2021 [13].

The disability-adjusted life years (DALY) weights or years lost due to premature death considered for each stage of the disease according to the WHO estimation for the disease [14]. The value of productivity loss obtained at each stage is the result of multiplying the respective weight by the average annual labor income value estimated in  USD $ 5.059 (DANE, 2024).

Total of economic burden of CKD and T2D disease including renal outcomes and CVD events in 2024 US dollars per patient in time horizon of 37 years were:

### Figure 4. Economic burden of CKD and T2D taking into account cardiovascular events
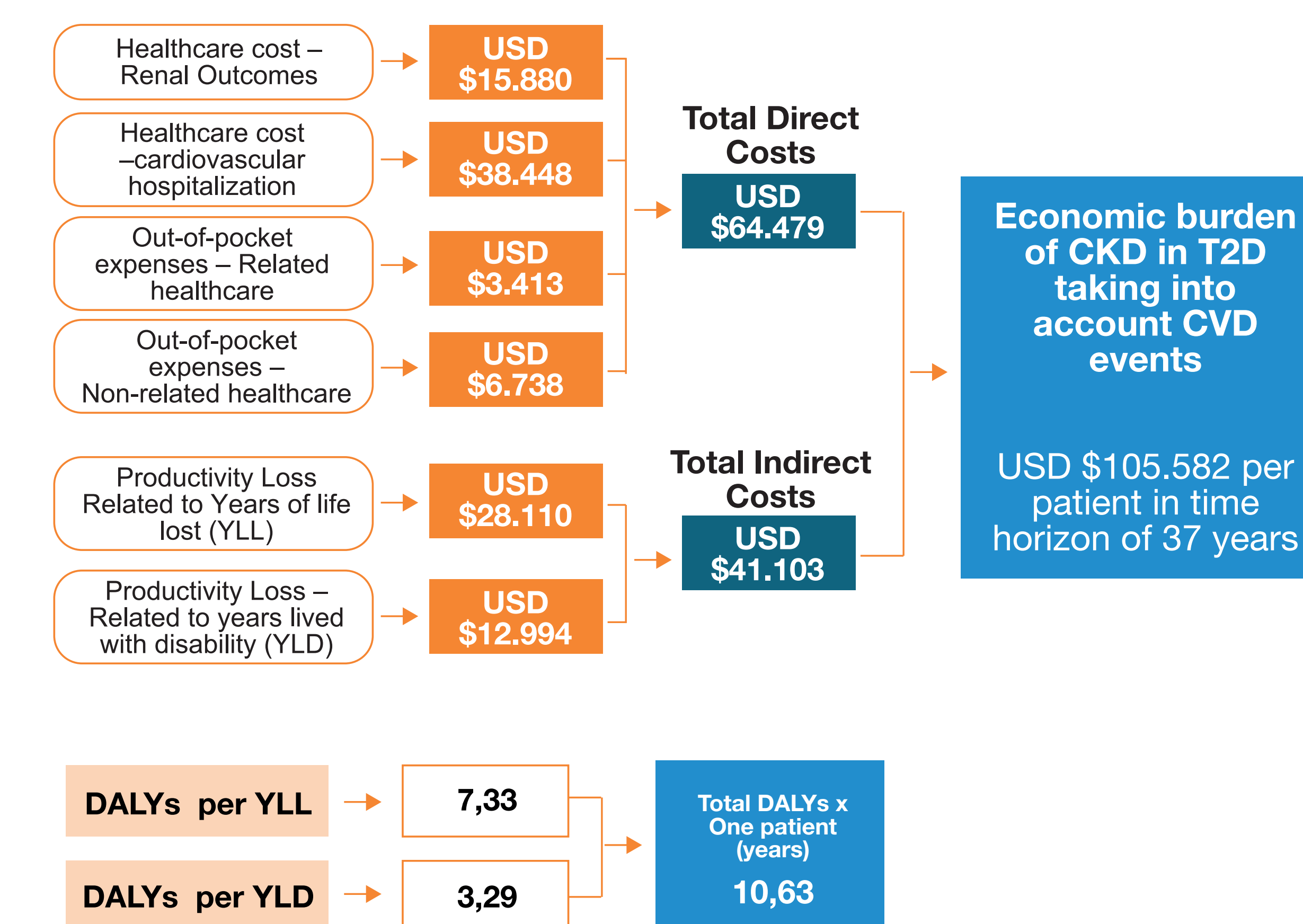


## Conclusions

Economic burden of CKD and T2D associated with hospitalization for cardiovascular events in Colombia is approximately USD$105.582 per patient in time horizon of 37 years.

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