GEORGIAN
MEDICAL
NEWS

ISSN 1512-0112

NO 2 (372) Февраль 2026

ТБИЛИСИ - NEW YORK

ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии
საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

Monthly Georgia-US joint scientific journal published both in electronic and paper
formats of the Agency of Medical Information of the Georgian Association of Business Press.
Published since 1994. Distributed in NIS, EU and USA.

GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.
GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.
ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned
Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman** (**Кириллица**), ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ,რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

GEORGIAN MEDICAL NEWS
NO 2 (371) 2026

Содержание:

GEORGIAN MEDICAL NEWS
No 1 (370) 2026

GLOBAL, REGIONAL, AND NATIONAL BURDEN OF CHRONIC KIDNEY DISEASE DUE TO TYPE 2 DIABETES MELLITUS, 1990-2021, WITH FORECASTS TO 2035: A FORECASTING STUDY FOR THE GLOBAL BURDEN OF DISEASE STUDY 2021

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Abstract.

Importance: Chronic kidney disease (CKD) attributable to type 2 diabetes mellitus (T2DM) represents a growing global health concern. However, comprehensive long-term epidemiological trends and projections, stratified by sociodemographic and geographic variables, remain inadequately delineated.

Objective: To evaluate the global, regional, and national burden of CKD due to T2DM from 1990 to 2021, and to forecast its trends through 2035 using Bayesian age-period-cohort (BAPC) modeling.

Design, Setting, and Participants: This population-based observational study used data from the Global Burden of Disease Study 2021 (GBD 2021), which includes 204 countries and territories across five sociodemographic index (SDI) quintiles and 21 GBD regions. The study covers the period 1990–2021 with projections to 2035.

Exposure: Diagnosis of T2DM mellitus as an underlying cause for CKD.

Main Outcome Measures: Incident and prevalent cases, mortality, and disability-adjusted life-years (DALYs) attributable to T2DM-related CKD. Age-standardized incidence (ASIR), prevalence (ASPR), mortality (ASDR), and DALY (ASR) rates were computed, alongside estimated annual percentage changes (EAPC).

Results: From 1990 to 2021, the global number of incident CKD cases due to T2DM increased by 167.2%, while the ASIR rose by 21.0% (EAPC: 0.61). Prevalent cases nearly doubled (+85.1%), although ASPR declined slightly (−5.1%, EAPC: −0.17). Deaths surged by 222.6%, and ASDR increased by 37.8% (EAPC: 1.17). DALYs rose by 173.6%, with a 24.0% increase in ASR (EAPC: 0.81). Males and older adults consistently exhibited higher burden across all indicators. Low- and middle-SDI nations experienced the most pronounced burden growth, yet high-SDI regions also registered substantial increases in mortality and DALYs.

Conclusions and Relevance: Projections to 2035 suggest a continued escalation, with incident cases exceeding 2.6 million and deaths surpassing 700,000 annually by mid-century. These findings highlight the importance of targeted prevention, early detection, and improved management strategies, particularly in high-growth regions and vulnerable populations.

Key words. Type 2 diabetes, chronic kidney disease, global burden of disease, disability-adjusted life years, forecasting.

Key Points.

Question: What are the long-term global, regional, and national trends in CKD attributable to T2DM mellitus from 1990 to 2021, and how will this burden evolve through 2035?

Findings: This comprehensive population-based analysis, utilizing data from the GBD 2021 and employing BAPC modeling, revealed a 167% increase in incident CKD cases attributable to T2DM globally between 1990 and 2021. Concurrently, mortality and DALYs demonstrated substantial escalation during this period. Modeled projections suggest that by 2035, the global prevalence of T2DM-related CKD will exceed 120 million cases, with annual incident cases surpassing 2.6 million and mortality exceeding 700,000 deaths.

Meaning: The global burden of CKD attributable to T2DM continues to rise, particularly in low- and middle-income countries. Without targeted interventions in diabetes control and kidney disease prevention, the associated health and economic challenges are expected to intensify through mid-century.

Introduction.

Chronic Kidney Disease (CKD) is a disease characterized by progressive decline in kidney function. As kidney impairment advances, a constellation of clinical manifestations emerges, most notably a substantially elevated risk of cardiovascular morbidity and mortality [1]. It may ultimately progress to a state requiring dialysis or kidney transplantation, leading to a higher risk of death. Epidemiological data from the Global Burden of Disease (GBD) study consistently rank CKD among the leading contributors to global disease burden, establishing it as a critical public health challenge worldwide [2]. Notably, among the causes of CKD, diabetes has become one of the primary factors [3]. The damage to renal microvasculature caused by hyperglycemia plays a key role in the development and progression of CKD. Given that diabetes is among the leading causes of CKD globally, the accelerating expansion of T2DM is likely to translate into further growth in the attributable CKD burden over coming decades.

Type 2 diabetes mellitus (T2DM) is expanding rapidly worldwide. The latest Global Burden of Disease (GBD) 2021 analysis estimated 529 million people living with diabetes in 2021 and projects >1.31 billion by 2035, with the highest age-standardized prevalence anticipated in North Africa and the Middle East and in Latin America and the Caribbean; most cases will be T2DM. These trends-driven by population ageing, obesity, and urbanization-portend sustained upward pressure on kidney disease burden unless prevention and kidney-protective therapies scale rapidly [4]. Concurrently, therapeutic advances now extend beyond glucose lowering: SGLT2 inhibitors and GLP-1 receptor agonists reduce kidney disease progression and major cardiovascular events in adults with T2DM and CKD and have informed KDIGO 2022 recommendations. Yet global access and coverage remain uneven, particularly in regions with the fastest projected diabetes growth, underscoring the need for timely, policy-relevant burden estimates [5-8].

Against this backdrop, we specifically quantify chronic kidney disease attributable to T2DM-the GBD comparative risk assessment construct that estimates the share of CKD causally assigned to diabetes exposure-across 204 countries and territories from 1990–2021. We then generate forecasts to 2035 using a Bayesian age-period-cohort (BAPC) framework. By distinguishing attributable CKD from clinically defined diabetic kidney disease (DKD) and by providing long-run projections stratified by super region, SDI, sex and age, our study addresses a critical evidence gap for policy and resource planning.

Materials and Methods.

Study Design and Framework: This is a population-based descriptive and forecasting study using GBD 2021 estimates. Our outcome is the burden of CKD attributable to type 2 diabetes mellitus (T2DM) as quantified in the GBD comparative risk assessment (CRA) framework. Specifically, GBD estimates population-attributable fractions (PAFs) for T2DM and applies them to CKD outcomes to derive attributable incidence, prevalence, deaths, and DALYs with uncertainty. These CRA-attributable estimates are distinct from clinically diagnosed diabetic kidney disease (DKD); our analyses do not use individual-level clinical criteria (e.g., eGFR/UACR) and therefore do not identify clinical DKD phenotypes.

Data Sources:

The data were sourced from the GBD 2021 database, provided by the Institute for Health Metrics and Evaluation (IHME), covering 204 countries and territories. The database includes various types of data sources (such as demographic statistics, death registries, hospital records, and research literature). All data underwent standardized processing and quality control by IHME.

Case Definition:

CKD is defined as chronic structural and functional abnormalities of the kidneys caused by various etiologies, persisting for more than 3 months. These abnormalities include pathological damage (with or without altered glomerular filtration rate), hematologic or urinary component abnormalities, and imaging abnormalities (ICD-10: N18). For clinical context, diabetic kidney disease (DKD) refers to kidney disease occurring in individuals with diabetes and is commonly identified by persistent reduction in kidney function and/or albuminuria (e.g., GFR <60 mL/min/1.73m² and/or UACR≥30 mg/g for≥3 months), after exclusion of alternative primary kidney diseases. However, the present study does not estimate clinically diagnosed DKD. Instead, we quantified the burden of CKD attributable to type 2 diabetes mellitus (T2DM) using the GBD study's comparative risk assessment (CRA) framework. This CRA construct combines (1) the causal association strength (relative risks [RRs]) linking T2DM exposure to CKD outcomes and (2) the population attributable fraction (PAF); PAFs are then applied to CKD incidence, deaths, and DALYs to derive attributable burden estimates.

Measures and Indicators:

The primary evaluation metrics included: Incidence and age-standardized incidence rate (ASIR), Prevalence and age-standardized prevalence rate (ASPR), Mortality and age-standardized mortality rate (ASMR), Disability-adjusted life years (DALYs) and age-standardized DALY rate (ASDR). All indicators were stratified by sex, age group, SDI quintile, region, and country for analysis.

GBD estimation framework:

We used GBD 2021 released estimates and uncertainty draws. Non-fatal CKD outcomes (incidence, prevalence) are synthesized in GBD with DisMod-MR 2.1, a Bayesian disease-modeling meta-regression that enforces internal consistency across incidence, prevalence, remission, and mortality by age, sex, location, and year, while borrowing strength across data sources and correcting for study-level bias where applicable. Cause-specific mortality for CKD is modeled in GBD using the Cause of Death Ensemble model (CODEm), which fits and ensembles multiple model classes with covariate selection and out-of-sample validation to maximize predictive performance. Covariate and exposure surfaces (where needed) are generated using spatiotemporal Gaussian process regression (ST-GPR) to smooth noisy series across age–time–location. For attribution to type 2 diabetes, GBD applies the comparative risk assessment (CRA) framework to estimate population-attributable fractions (PAFs) from the exposure distribution and causal relative risks; PAFs are then applied to CKD outcomes and DALYs, with 1,000 posterior draws propagated through all components to form 95% uncertainty intervals. We used these standard GBD definitions and did not modify the underlying GBD models.

Geographic and SDI stratification:

Analyses followed the GBD 2021 location hierarchy at the 21-region level and by five SDI quintiles. Specifically, we report by the 21 GBD regions: High-income Asia Pacific; High-income North America; Western Europe; Australasia; Central Europe; Eastern Europe; Andean Latin America; Caribbean; Central Latin America; Southern Latin America; Tropical Latin America; North Africa & Middle East; South Asia; East Asia; Southeast Asia; Oceania; Central Asia; Central Sub-Saharan Africa; Eastern Sub-Saharan Africa; Southern Sub-Saharan Africa; Western Sub-Saharan Africa. The Sociodemographic Index (SDI) is a standardized composite measure (range 0–1) combining income per capita, average educational attainment among persons aged ≥15 years, and fertility under age 25; locations are grouped into five quintiles (low, low-middle, middle, high-middle, high) per IHME definitions used in GBD 2021. We adopt these definitions unchanged [9].

Age standardization:

We computed age-standardized rates (ASRs) by the direct method, applying age-specific s (r_a) to the GBD global standard population weights (w_a) for 5-year age groups from <5, 5–9, ..., 85–89, 90–94, 95+; the ASR equals $\sum_a w_a r_a$ (reported per 100,000). The GBD global standard population is the synthetic age distribution used across GBD analyses to enable valid comparisons over time and between locations; GBD explicitly defines ASRs as rates adjusted to the GBD global standard population. We used this same standard for all metrics (ASIR, ASPR, ASMR, ASDR), sexes, locations, and years. References and documentation are provided in the GBD 2021 Data & Tools Guide and IHME's GBD methods resources.

Trend Analysis:

The Estimated Annual Percentage Change (EAPC) was used to assess trends in age-standardized rate (ASR) metrics between 1990 and 2021. EAPC was calculated using a linear regression model with log-transformed ASR as the dependent variable and calendar year as the independent variable.

Uncertainty estimation and interpretation:

All GBD-sourced quantities (incident and prevalent cases, deaths, DALYs, and their rates) are reported with 95% uncertainty intervals (UIs) defined as the 2.5th and 97.5th percentiles of the ordered set of 1,000 posterior draws released with GBD 2021; uncertainty from all model components is propagated to these draws. For pairwise differences (e.g., between years, sexes, or regions), we compute the difference for each draw and take the 2.5th-97.5th percentiles of that draw-wise difference to form a UI for the contrast. A UI that excludes 0 indicates a difference/increase/decrease with high certainty under the GBD framework [10]. In the main text we highlight changes or differences only when the 95% CI/UI excludes the null (0% for EAPC; 0 for contrasts). When the interval includes the null, we describe the finding as "no clear change/difference" and, unless directly pertinent to a prespecified aim (e.g., documenting stability in comparator settings), relegate the numeric estimates to the Supplement. This rule applies to all metrics (ASIR, ASPR, ASMR, ASDR) and all subgroup contrasts. We do not report p-values.

For temporal trends, we summarize changes using the EAPC derived from a log–linear regression of the ASR on calendar year:

$$\ln(\mathrm{ASR})=\alpha+\beta\cdot\mathrm{year}+\varepsilon,\quad \mathrm{EAPC}=100\times[\exp(\beta)-1]$$

We report the 95% CI for EAPC based on the regression standard error of β by convention, an EAPC CI entirely above 0 denotes an increasing trend; entirely below 0 denotes a decreasing trend; and including 0 denotes no clear change.

Forecasting and robustness assessment:

We projected age-specific rates (incidence, mortality, and DALY rates) to 2035 using a Bayesian age–period–cohort (BAPC) model implemented in R 4.4.2 with the BAPC and INLA packages. For each location×sex, incidence and mortality were modeled with Poisson likelihoods for age-specific counts using a log(population) offset, and DALY rates were modeled as log-rates with a Gaussian likelihood (with a sensitivity analysis reconstructing pseudo-counts to fit a Poisson model, yielding consistent conclusions). Age and period effects used second-order random-walk (RW2) priors and the cohort effect a first-order random-walk (RW1) prior; precision hyperpriors were log-Gamma (shape=1, rate=0.0005) in the base model, with sensitivity grids varying shape {0.5, 1, 2} and rate {0.0005, 0.001, 0.005} and additional runs using penalized-complexity (PC) priors. APC identifiability was addressed with sum-to-zero constraints on age/period/cohort deviations and a corner constraint on the linear drift. We compared candidate specifications (RW placements, hyperpriors) using WAIC and LCPO alongside posterior predictive checks and retained the best-fitting model subject to epidemiological plausibility and trajectory stability. Validation used rolling-origin back-testing: for each origin year from 2005 to 2016 we trained on years $\leq t$ and predicted $t+1\ldots t+5$, summarizing MAE, RMSE, MAPE, empirical 95% interval coverage, calibration slope/intercept, and CRPS across age groups, sexes, locations, and origins; sensitivity analyses varying smoothness and projection windows produced similar rankings and error profiles. Forecasts are reported as posterior medians with 95% credible intervals (CrIs); all projection figures display shaded 95% CrIs. Predicted age-specific rates were aggregated to age-standardized rates using the GBD standard population.

Attribution to T2DM:

We quantified CKD attributable to type 2 diabetes (T2DM) using the GBD comparative risk assessment (CRA) framework. For each location, year, sex, and age group, we computed population attributable fractions (PAFs) as

$$\mathrm{PAF}=\frac{\sum_a p_a(\mathrm{RR}_a-1)}{\sum_a p_a \mathrm{RR}_a}$$

where p_a is T2DM exposure (GBD 2021 modeled prevalence) and RR_a are meta-analytic relative risks linking diabetes with CKD outcomes as curated in GBD; uncertainty from exposure and RRs is propagated through 1,000 posterior draws, and draw-wise PAFs are applied to CKD incidence, deaths, and DALYs to obtain attributable quantities and 95% UIs (2.5th–97.5th percentiles). In line with GBD practice, RRs are applied consistently across locations and years, with age/sex stratification where available.

Reporting guidelines:

This observational global estimation and forecasting study adheres to STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) and to GATHER (Guidelines for Accurate and Transparent Health Estimates Reporting). Key elements—data sources and eligibility (GBD 2021 scope), variable and indicator definitions (ASR metrics; attribution methods), handling of missingness/uncertainty (1,000 draws; 95% UIs/CrIs), analytical methods (BAPC specification, priors, validation), and limitations—are detailed in the Methods and Discussion.

Results.

Global trends.

Incidence:

Globally, both the number of incident cases and the ASIR of CKD due to T2DM increased substantially between 1990 and 2021. Incident cases rose from 753,106 (UI 680,930–826,928) in 1990 to 2,012,025 (1,857,800-2,154,288) in 2021. Over the same period, ASIR increased from 19.07 (17.28-20.83) to 23.07 (21.40-24.72) per 100,000 population, representing a 167.16% (153.53-182.63) increase in incident cases and a

20.97% (14.99-27.49) increase in ASIR. The EAPC in ASIR was 0.61 (0.60-0.63), indicating a sustained upward trend over three decades (Table 1). Sex-specific analysis showed consistently higher disease burden among males, who exhibited both greater absolute case numbers and marginally elevated ASIRs compared to females. Age-stratified analysis identified a unimodal distribution of incidence, with peak rates occurring in the 65-74-year age group for both sexes (Figure 1B).

Prevalence:

From 1990 to 2021, the global prevalence of CKD due to T2DM increased substantially in absolute numbers, while the ASPR showed a modest decline. Prevalent cases increased from 58,105,268 (UI 53,056,992-63,286,818) in 1990 to 107,559,955 (99,170,797-115,994,732) in 2021, representing an 85.11% (78.13-91.41) increase. ASPR declined from 1,327.22 (1,223.26-1,439.42) to 1,259.63 (1,161.99-1,359.92) per 100,000 population, a 5.09% reduction (UI −7.46 to −2.98), with an EAPC of −0.17(−0.20 to −0.13), indicating a modest reduction in individual-level risk after adjusting for demographic shifts (Table S1). Subsequently, the burden was higher in males across nearly all age groups, particularly those older than 55 years. The 65-74-year age group accounted for the highest number of prevalent cases, and the highest ASPR was observed in individuals aged 75-79 years (Figure 1A).

Mortality:

Between 1990 and 2021, the global mortality burden from CKD attributable to T2DM increased markedly in both total number of deaths and the age-standardized mortality rate (ASMR). Global deaths increased from 147,970 (UI 124,179-176,413) to 477,273 (401,541-565,951), while ASMR rose from 4.15 (3.50-4.94) to 5.72 (4.83-6.79) per 100,000 population. This corresponds to a 222.55% (177.43-253.83) increase in total deaths and a 37.79% (19.17-49.63) increase in ASMR. EAPC for ASMR was 1.17 (1.10-1.24), confirming a consistent upward trend (Table S2). Mortality was consistently higher in males, with the sex gap widening with age, especially after 65 years. The number of deaths increased markedly after age 45, peaking between 65 and 84 years. ASMR rose linearly with age, reaching its highest levels in individuals aged 80 years and older (Figure 1C).

DALYs:

DALYs attributable to CKD due to T2DM increased significantly from 1990 to 2021, reflecting a growing public health burden. DALYs rose from 4,122,919 (UI 3,498,980-4,818,958) in 1990 to 11,278,935 (9,682,785-13,103,871) in 2021, an increase of 173.57% (140.54-194.35). The global ASDR increased from 105.71 (90.68-122.67) to 131.08 (112.75-152.49) per 100,000 population, a 24.00% increase (9.26-33.00), with an EAPC of 0.81 (0.74-0.87) (Table S3). The increase was primarily driven by population ageing, rising diabetes prevalence, and insufficient management of CKD progression. The burden was consistently higher in males, particularly beyond 55 years. DALYs increased sharply from age 45 onwards, peaking between 65 and 79 years. ASDR increased exponentially with age, reaching its peak among individuals aged 80-89 years (Figure 1D).

SDI Regional Trends.

Incidence:

Between 1990 and 2021, the number of incident CKD cases due to T2DM increased across all five sociodemographic index (SDI) quintiles, with the largest relative growth observed in lower SDI regions. In high SDI countries, incident cases increased from 289,954 (95% UI 263,980-316,807) to 595,271 (547,943-636,879), a 105.30% rise (93.99-117.68). The ASIR increased from 25.59 to 28.34 per 100,000 population, a 10.75% increase (4.83-17.36), with an EAPC of 0.28 (0.24-0.33). In high-middle SDI countries, incident cases rose by 157.48% (142.69-175.18), ASIR increased from 15.72 to 20.09 per 100,000 (27.83% increase, 20.71-36.27), and EAPC was 0.91 (0.88-0.95). Middle SDI countries experienced the fastest growth in incidence, with cases rising from 181,844 to 635,311 (249.37% increase, 224.15-276.80), ASIR increasing by 33.96% (25.11-43.94), and the highest EAPC at 0.99 (0.97-1.02). In low-middle SDI countries, incident cases increased by 210.05% (195.02-226.94), ASIR rose by 33.57% (27.59-40.00), and EAPC was 0.77 (0.70-0.85). Low SDI countries also demonstrated notable growth, with incident cases increasing by 181.08% (165.79-198.45), ASIR rising by 26.76% (20.00-34.42), and an EAPC of 0.65 (0.56-0.74) (Table 1, Figure 2B).

Prevalence:

All five SDI levels saw marked increases in the number of prevalent CKD cases due to T2DM between 1990 and 2021. However, ASPRs generally declined, indicating that increases in prevalence were largely driven by demographic factors and diabetes expansion rather than increases in individual-level risk. In high SDI countries, prevalent cases rose from 11,068,895 (95% UI 10,251,403-11,847,690) to 18,097,946 (16,763,917-19,359,376), a 63.50% increase (59.59-67.22). ASPR declined from 1,037.34 to 997.07 per 100,000 population (−3.88%, −5.62 to −2.23), with an EAPC of −0.09 (−0.14 to −0.05). In high-middle SDI countries, prevalence increased by 59.14% (51.57-65.58), ASPR declined by −8.99% (−11.95 to −6.58), and EAPC was −0.25 (−0.32 to −0.19). In middle SDI countries, prevalence increased by 102.56%, ASPR declined by -7.00% (-9.53 to -4.81), and EAPC was −0.20 (−0.25 to −0.16). In low-middle SDI countries, prevalent cases rose by 98.80% (91.34-105.59), ASPR declined from 1,586.44 to 1,474.59 (−7.05%, −9.36 to −4.89), and EAPC was −0.31 (−0.36 to −0.27). Low SDI countries saw the greatest absolute increase in prevalence (113.05%, 106.34–119.42), ASPR declined by −6.34% (−8.66 to −4.41), and EAPC was −0.28 (−0.32 to −0.25) (Table S1, Figure 2A).

Mortality:

Across all SDI quintiles, the number of CKD-related deaths due to T2DM increased substantially from 1990 to 2021. However, trends in ASMRs and EAPCs varied widely, reflecting differences in mortality control across development levels. In high SDI countries, deaths increased from 26,431 (95% UI 21,843-31,511) to 111,565 (93,260-132,404), a 322.09% increase (275.84-369.99). ASMR rose from 2.36 to 4.62 per 100,000, a 95.35% increase (79.50-113.48), with the highest EAPC among all quintiles (2.51, 2.37-2.66). In high-middle

Table 1: *Incidence of Chronic kidney disease due to diabetes mellitus type 2 Between 1990 and 2021 at the Global and Regional Level.*

Location	**1990**		**2021**		**Percentage change in number between 1990 and 2021**	**Percentage change in rates between 1990 and 2021**	**EAPC**
	Number	**Rates**	**Number**	**Rates**			
Prevalence							
Global	753106.40(680930.46,826928.18)	19.07(17.28,20.83)	2012024.53(1857800.04,2154287.72)	23.07(21.40,24.72)	167.16(153.53,182.63)	20.97(14.99,27.49)	0.61(0.60,0.63)
SDI							
High SDI	289954.13(263979.54,316806.57)	25.59(23.30,27.81)	595270.86(547942.95,636879.14)	28.34(26.19,30.30)	105.30(93.99,117.68)	10.75(4.83,17.36)	0.28(0.24,0.33)
High middle SDI	156965.51(140078.54,172676.76)	15.72(14.12,17.28)	404153.75(369299.53,435463.95)	20.09(18.43,21.59)	157.48(142.69,175.18)	27.83(20.71,36.27)	0.91(0.88,0.95)
Middle SDI	181843.98(161584.47,203076.18)	17.13(15.38,18.97)	635310.50(582063.19,685432.59)	22.95(21.15,24.58)	249.37(224.15,276.80)	33.96(25.11,43.94)	0.99(0.97,1.02)
Low middle SDI	96144.69(85819.89,107293.14)	15.13(13.54,16.71)	298098.79(270253.90,326985.36)	20.20(18.31,22.05)	210.05(195.02,226.94)	33.57(27.59,40.00)	0.77(0.70,0.85)
Low SDI	27500.19(24485.69,30719.52)	11.90(10.68,13.16)	77297.98(69537.24,84888.84)	15.09(13.65,16.60)	181.08(165.79,198.45)	26.76(20.00,34.42)	0.65(0.56,0.74)
Regions							
Andean Latin America	3348.62(2929.90,3785.80)	16.41(14.40,18.50)	18007.81(16150.50,20130.55)	30.50(27.39,34.10)	437.77(393.34,489.42)	85.88(70.26,103.58)	2.31(2.20,2.41)
Australasia	6562.47(5920.18,7295.09)	26.65(24.07,29.55)	16772.42(14864.10,18754.04)	30.30(26.99,33.93)	155.58(132.86,175.04)	13.72(4.67,22.17)	0.42(0.37,0.47)
Caribbean	4414.49(3972.44,4917.06)	16.71(14.99,18.62)	14678.65(13310.45,16052.19)	27.20(24.68,29.76)	232.51(209.48,257.51)	62.77(51.62,74.99)	1.70(1.60,1.80)
Central Asia	4556.54(3956.29,5216.72)	9.24(8.07,10.55)	14528.26(12630.78,16383.67)	16.37(14.60,18.22)	218.84(199.58,240.90)	77.14(67.20,88.55)	2.02(1.86,2.17)
Central Europe	20175.17(17840.53,22635.13)	13.15(11.67,14.66)	49402.79(44902.95,54054.33)	22.11(20.24,23.92)	144.87(126.89,167.03)	68.19(57.49,81.18)	1.54(1.40,1.67)
Central Latin America	24703.60(22032.26,27768.73)	28.46(25.42,31.90)	106519.01(98854.93,114268.00)	41.31(38.40,44.26)	331.19(292.77,374.92)	45.13(32.75,59.53)	1.32(1.26,1.39)
Central Sub-Saharan Africa	2078.86(1787.22,2378.99)	9.22(8.13,10.39)	6880.60(5958.07,7821.24)	12.58(11.11,14.18)	230.98(206.09,257.98)	36.37(26.62,47.34)	0.94(0.77,1.12)
East Asia	134292.51(119023.01,150087.85)	15.32(13.67,16.99)	373610.92(340685.92,402345.45)	16.59(15.26,17.82)	178.21(155.85,205.14)	8.29(0.50,17.94)	0.42(0.35,0.50)
Eastern Europe	24272.31(21290.30,27560.33)	8.65(7.70,9.73)	52339.23(47044.28,58222.31)	15.29(13.81,16.81)	115.63(100.93,130.34)	76.72(65.88,86.34)	1.89(1.82,1.97)
Eastern Sub-Saharan Africa	6723.73(6005.47,7549.74)	9.13(8.20,10.08)	18825.31(16932.81,20749.97)	11.41(10.30,12.55)	179.98(162.68,199.75)	24.99(17.16,33.72)	0.59(0.44,0.73)
High-income Asia Pacific	59317.27(53817.71,64923.48)	28.98(26.31,31.63)	133311.69(121632.43,145016.08)	29.32(26.88,31.66)	124.74(110.88,139.35)	1.18(-3.23,6.71)	0.07(0.02,0.12)
High-income North America	107854.91(96877.08,119411.37)	30.01(26.91,33.08)	216863.66(198070.32,236861.46)	32.38(29.68,35.16)	101.07(87.76,116.99)	7.91(0.60,16.50)	0.16(0.08,0.24)
North Africa and Middle East	44918.68(40072.49,50061.83)	26.20(23.49,28.80)	199623.39(182526.91,218247.29)	42.80(39.23,46.54)	344.41(318.37,374.39)	63.38(54.48,74.02)	1.54(1.46,1.62)
Oceania	382.25(331.52,435.18)	12.09(10.63,13.61)	1223.46(1066.46,1377.47)	15.47(13.75,17.19)	220.07(191.37,249.05)	27.92(16.64,39.16)	0.75(0.68,0.82)
South Asia	89412.91(79455.56,99864.97)	14.59(13.09,16.14)	267934.35(239653.87,294287.88)	17.63(15.82,19.36)	199.66(182.57,219.55)	20.85(14.72,27.27)	0.36(0.26,0.45)
Southeast Asia	38934.01(34827.74,43212.95)	14.85(13.31,16.45)	152649.90(138455.49,167650.14)	22.31(20.28,24.32)	292.07(266.69,320.56)	50.29(40.51,61.07)	1.30(1.25,1.35)
Southern Latin America	10244.46(8983.14,11758.73)	21.98(19.30,25.16)	25927.73(23175.93,28694.40)	29.23(26.16,32.33)	153.09(127.34,181.97)	33.01(20.07,47.68)	1.09(0.97,1.21)
Southern Sub-Saharan Africa	4522.17(4050.37,5055.57)	16.59(14.92,18.44)	13773.65(12470.46,15069.89)	23.37(21.14,25.51)	204.58(188.35,222.33)	40.89(33.79,48.75)	1.01(0.86,1.17)
Tropical Latin America	18123.40(16212.08,20221.91)	19.22(17.20,21.41)	66482.96(60784.18,72038.98)	25.53(23.34,27.59)	266.83(239.14,304.88)	32.82(23.08,45.43)	0.87(0.81,0.92)
Western Europe	136706.17(123437.37,150729.97)	22.52(20.39,24.69)	228491.55(212548.16,245901.50)	23.91(22.18,25.74)	67.14(56.00,78.75)	6.21(-0.55,13.66)	0.23(0.18,0.28)
Western Sub-Saharan Africa	11561.88(10322.55,12856.89)	13.02(11.70,14.40)	34177.18(30688.34,37596.62)	17.29(15.60,19.04)	195.60(180.46,212.68)	32.80(25.71,40.22)	0.89(0.77,1.01)

SDI countries, deaths increased by 169.70% (120.17-213.53), ASMR rose by 21.54% (0.64-39.87), and EAPC was 0.73 (0.57-0.89). In middle SDI countries, deaths rose from 56,152 to 182,160 (224.40% increase, 164.58-265.78), ASMR increased modestly from 6.77 to 7.51 (10.99%, −9.44 to 23.65), and EAPC was 0.44 (0.37-0.52). Low-middle SDI countries experienced a 223.52% increase in deaths, ASMR increased by 31.24% (4.75-51.55), and EAPC was 0.89 (0.84-0.94). In low SDI countries, deaths rose from 13,362 to 29,491 (120.72% increase, 93.16-151.04), while ASMR remained relatively stable (from 7.16 to 7.36 per 100,000), a marginal 2.76% increase (−10.13 to 15.91), with an EAPC of 0.02 (−0.11 to 0.15) (Table S2, Figure 2C).

DALYs:

From 1990 to 2021, all SDI quintiles experienced significant increases in DALYs due to CKD from T2DM, though ASDR trends and EAPCs varied. In high SDI countries, DALYs rose from 692,418 (UI 588,252-796,294) to 2,202,413 (1,928,998-2,486,233), a 218.08% increase (194.09-242.35). ASDR increased from 62.47 to 102.65 per 100,000 population (64.31%, 53.89-74.81), with the highest EAPC of 1.90 (1.78-2.02). High-middle SDI countries saw DALYs increase by 121.59%, ASDR rose slightly from 78.21 to 84.71 (8.31%, -7.26 to 21.94), and EAPC was 0.37 (0.23-0.52). In middle SDI countries, DALYs increased by 183.36%, ASDR rose from 157.87 to 167.06 (5.82%, -10.75 to 16.44), and EAPC was 0.29 (0.22-0.37). In low-middle SDI countries, DALYs rose from 747,142 to 2,202,184 (194.75% increase, 145.31-235.42), ASDR increased from 125.03 to 155.33 (24.24%, 3.35-40.98), and EAPC was 0.71 (0.68-0.74). Low SDI countries had a DALY increase of 111.14% (89.26-137.06), while ASDR declined slightly from 166.43 to 160.88 (−3.33%, −13.70 to 8.02), with a negative EAPC of −0.21 (−0.31 to −0.12) (Table S3, Figure 2D).

Geographic Regional Trends.

Incidence:

From 1990 to 2021, the burden of incident CKD attributable to T2DM increased markedly across most GBD regions, with the most rapid rises observed in middle- and low-income regions. In Andean Latin America, incident cases increased from 3,349 (95% UI 2,930-3,786) to 18,008 (16,151-20,131), representing a 437.77% (393.34-489.42) increase. The ASIR rose from 16.41 to 30.50 per 100,000 population, an 85.88% increase (70.26-103.58), with an EAPC of 2.31 (2.20-2.41), among the highest globally. Central Latin America showed a 331.19% (292.77-374.92) increase in incident cases and a 45.13% (32.75-59.53) increase in ASIR, with an EAPC of 1.32 (1.26-1.39). In Central Asia, incident cases rose by 218.84% (199.58-240.90), ASIR by 77.14% (67.20-88.55), and EAPC was 2.02 (1.86-2.17). The Caribbean reported a 62.77% (51.62-74.99) increase in ASIR and an EAPC of 1.70 (1.60-1.80). Conversely, high-income regions like Western Europe exhibited only modest changes, with a 6.21% (−0.55 to 13.66) increase in ASIR and an EAPC of 0.23 (0.18-0.28). In East Asia, incident cases increased from 134,292 (95% UI 119,386-150,128) in 1990 to 373,611 (337,634-401,905) in 2021, and the ASIR increased from 12.96 to 19.49 per 100,000 population, with an EAPC of 0.42 (0.35-0.50), reflecting the influence of demographic changes rather than increasing individual-level risk. Southeast Asia experienced a 292.07% increase in incident cases, with ASIR increasing by 50.29% (40.51-61.07) and an EAPC of 1.30 (1.25-1.35)-the highest in the Asia-Pacific region. In South Asia, incident cases rose by 199.66% (182.57-219.55), ASIR increased by 20.85% (14.72-27.27), and EAPC was 0.36 (0.26-0.45). In high-income Asia Pacific countries (e.g., Japan, South Korea), incident cases increased by 124.74% (110.88-139.35), but ASIR remained largely stable (+1.18%, −3.23 to 6.71), with a low EAPC of 0.07 (0.02-0.12). Despite a smaller population, Oceania saw incident cases rise by 220.07% (191.37-249.05), ASIR increase by 27.92% (16.64-39.16), and EAPC of 0.75 (0.68-0.82) (Table 1, Figure 3B).

Prevalence:

Between 1990 and 2021, the number of prevalent CKD cases due to T2DM rose significantly in all GBD regions. However, most regions exhibited declining or stable ASPRs, indicating that total burden increases were primarily driven by population growth and rising diabetes prevalence. Regions with over 100% growth included North Africa and the Middle East (+143.59%), Central Latin America (+138.31%), Eastern Sub-Saharan Africa (+131.54%), and Western Sub-Saharan Africa (+127.30%). Nonetheless, ASPRs declined in many regions, and most EAPCs were negative, reflecting slight reductions in individual-level risk. In East Asia, prevalent cases increased by 75.96% (66.54-85.04), but ASPR declined by 13.12%, with an EAPC of −0.25 (−0.39 to −0.10). Southeast Asia recorded a 114.37% increase in cases and a 2.65% reduction in ASPR, with an EAPC of −0.18 (−0.23 to −0.13). In South Asia, prevalent cases increased by 103.65% (95.77-111.73), ASPR declined by 9.66%, and EAPC was −0.44 (−0.52 to −0.36)-the largest decline in the Asia-Pacific region. High-income Asia Pacific saw a 58.60% increase in cases and an ASPR decline of 11.80%, with an EAPC of −0.47 (−0.54 to −0.41). In Oceania, prevalence increased by 129.68% (119.44-140.62), ASPR declined by 4.28%, and EAPC was −0.15 (−0.16 to −0.13) (Table S1, Figure 3A).

Mortality:

Between 1990 and 2021, CKD-related deaths due to T2DM increased substantially across all GBD regions, though changes in ASMR varied markedly. High-income North America recorded the largest increases: a 596.18% rise in deaths (95% UI 499.10-709.23) and a 259.94% increase in ASMR, with an EAPC of 4.71. Central Latin America experienced a 422.05% increase in deaths, a 49.89% rise in ASMR, and an EAPC of 1.82. Eastern Europe and Central Asia also reported more than 200% increases in deaths and EAPCs above 2.90. By contrast, East Asia, high-income Asia Pacific, and Southern Latin America showed stable or declining ASMRs. In East Asia, deaths increased by 149.66%, while ASMR declined by 16.63%, with an EAPC of -0.53 (-0.63 to -0.44). Southeast Asia recorded a 248.93% rise in deaths, ASMR increased by 31.45%, and EAPC was 0.90 (0.86-0.94). South Asia experienced a 248.59% increase in deaths, ASMR rose by 28.48%, and EAPC was 0.72 (0.61-0.84). In high-income Asia Pacific, deaths rose by 201.51%, ASDR declined by 18.27%, and EAPC was −0.57 (−0.69 to −0.44). In Oceania, deaths increased by 237.35%, ASMR rose by 27.25%, and EAPC was 0.69 (0.58-0.81) (Table S2, Figure 3C).

DALYs:

From 1990 to 2021, the total DALYs due to CKD caused by T2DM increased markedly across all GBD regions, although ASDR trends varied substantially. High-income North America recorded the largest growth, with DALYs increasing by 408.43% (UI 357.41-469.54) and ASDR by 168.37%, with an EAPC of 3.66. Central Latin America showed a 401.34% increase in DALYs, 56.58% in ASDR, and an EAPC of 1.86. Andean Latin America, Central Asia, and the Caribbean also had EAPCs above 1.0. Conversely, East Asia reported a 20.88% reduction in ASDR (EAPC −0.65, 95% CI −0.76 to −0.55), and high-income Asia Pacific had an 18.89% decline (EAPC −0.49, −0.63 to −0.36). In Southern Latin America, ASDR declined by 8.30%. Within the Asia-Pacific region, East Asia's DALYs rose by 107.87% (UI 68.86-149.50), while ASDR declined from 158.73 to 125.58 per 100,000. Southeast Asia experienced a 218.98% increase in DALYs, ASDR rose by 23.47%, and EAPC was 0.72 (0.69-0.75). South Asia had a 215.46% increase in DALYs, ASDR rose by 22.08%, and EAPC was 0.60 (0.54-0.66). In high-income Asia Pacific, DALYs increased by 119.26%, ASDR declined from 92.69 to 75.19, and EAPC was −0.49 (−0.63 to −0.36). Oceania reported a 218.14% increase in DALYs, ASDR increased from 250.33 to 309.80 (+23.76%), and EAPC was 0.63 (0.52-0.74) (Table S3, Figure 3D).

National Trends.

Incidence:

Among the 204 countries and territories analyzed, most experienced substantial increases in the number of incident CKD cases attributable to T2DM between 1990 and 2021. However, ASIRs remained stable or declined in many countries, suggesting that rising case counts were largely driven by demographic and epidemiological transitions. Countries with the greatest increases in ASIR included Greenland (EAPC: 0.89), Canada (EAPC: 0.35), and Argentina (EAPC: 0.29). In contrast, the most pronounced declines were observed in Italy (EAPC: −0.60), Ireland (EAPC: −0.51), China (EAPC: −0.24), and India (EAPC: −0.48).

In the Asia-Pacific region, China's incident cases increased from 127,561 to 354,157, despite a decline in ASIR from 1,214.76 to 1,053.92 per 100,000 (EAPC: −0.24). India's incident cases nearly doubled from 75,874 to 222,793, while ASIR declined from 1,777.93 to 1,586.69 (EAPC: −0.48). In Indonesia, cases rose by 113.49%, accompanied by a slight ASIR decrease of −2.27% (EAPC: −0.25). Japan, Malaysia, South Korea, and the Philippines all reported over 100% increases in case counts, with corresponding reductions in ASIRs. Notably, Malaysia's ASIR declined only marginally (EAPC: −0.01), while South Korea saw an ASIR drop of −11.09% (EAPC: −0.59) (Table S4, Figure 4B, Figure S2).

Prevalence:

Across most countries, the absolute number of prevalent CKD cases due to T2DM increased markedly between 1990 and 2021. However, the ASPR remained stable or declined in many settings, suggesting that population growth and increased diabetes prevalence were the main drivers of the total burden. In 2021, the highest ASPRs were observed in Pacific Island nations, including the Marshall Islands (3,057.63 per 100,000), Micronesia (3,009.87), and Kiribati (2,849.42), reflecting the region's extreme diabetes burden and limited nephrology care access. The lowest ASPRs were found in Niger (359.90), Chad (379.62), and Guinea (400.25), likely influenced by underdiagnosis and competing early mortality risks.

In Asia-Pacific, China's prevalent cases increased from 37,040,156 to 63,313,187 (+70.91%), while ASPR declined from 1,214.76 to 1,053.92 (EAPC: −0.24). India experienced an 84.85% increase in cases, with ASPR falling from 1,712.63 to 1,547.31 (EAPC: −0.44). Other countries with similar trends included Japan (ASPR change: −10.99%, EAPC: −0.39), South Korea (−11.80%, EAPC: −0.47), Indonesia (−4.57%, EAPC: −0.17), and the Philippines (−7.66%, EAPC: −0.35). Vietnam reported a 131.83% increase in cases and an ASPR increase of 8.05% (EAPC: 0.25) (Table S5, Figure 4A, Figure S1).

Mortality:

From 1990 to 2021, CKD-related deaths due to T2DM rose across nearly all countries. However, trends in the ASMR varied widely. High-income and upper-middle-income countries saw substantial increases in ASDR, whereas some low-income countries recorded minor changes or declines, potentially due to early mortality from other causes or limited diagnostic capacity. In 2021, the highest ASMRs were observed in the Marshall Islands (94.77 per 100,000), Micronesia (91.63), and Kiribati (85.12), while the lowest were reported in Niger (1.57), Guinea-Bissau (1.67), and Guinea (1.70).

Within Asia-Pacific, China's deaths rose from 47,774 to 115,064 (+140.94%), with ASMR decreasing from 6.99 to 5.83 (EAPC: −0.53). In India, deaths increased by 248.59%, with an ASMR rise from 4.10 to 5.26 (EAPC: 0.72). Japan, South Korea, and Malaysia all experienced more than 200% increases in death counts, although Japan and South Korea recorded notable ASMR reductions. Indonesia, the Philippines, and Vietnam experienced sharp increases in both death counts and ASMRs, with EAPCs ranging from 0.85 to 1.06 (Table S6, Figure 4C, Figure S3).

DALYs:

From 1990 to 2021, most countries experienced more than a twofold increase in total DALYs attributable to CKD due to T2DM. However, changes in ASDR varied substantially. The highest ASDRs in 2021 were in the Marshall Islands (2,213.44 per 100,000), Micronesia (2,091.27), and Kiribati (1,987.56), underscoring the extreme CKD burden in these small island nations. Conversely, the lowest ASDRs were reported in Niger (132.84), Guinea-Bissau (136.90), and Mali (140.73).

In Asia-Pacific, China's DALYs increased from 1,297,562 to 2,697,278 (+107.87%), with ASDR declining from 158.73 to 125.58 (EAPC: −0.65). India's DALYs rose from 626,652 to 1,976,809 (+215.46%), with ASDR increasing from 110.09 to 134.39 (EAPC: 0.60). Japan (ASDR: −18.89%, EAPC: −0.49), South Korea (−17.06%, EAPC: −0.53), and China all recorded reductions in DALY rates, whereas Indonesia, the Philippines, and Vietnam reported increases in both DALYs and ASDRs, with EAPCs above 0.80 (Table S7, Figure 4D, Figure S4).

Future Burden Projections Based on BAPC Modelling.

According to projections based on the BAPC model, the global burden of CKD attributable to T2DM is expected to continue rising through 2035. The number of individuals living with CKD due to T2DM is projected to increase from approximately 108 million in 2021 to over 120 million by 2035. The global ASPR is also forecasted to rise modestly, from around 1,260 per 100,000 population in 2021 to nearly 1,400 per 100,000 by 2035 (Figure 5A and Table S8).

Globally, the number of incident CKD cases due to T2DM is predicted to grow from roughly 2 million in 2021 to over 2.6 million in 2035. While the absolute number of new cases continues to rise, the ASIR is also expected to increase steadily, from 23.07 per 100,000 population in 2021 to approximately 36 per 100,000 by 2035 (Figure 5B and Table S8).

In terms of mortality, approximately 150,000 deaths were attributable to CKD due to T2DM in 1990. This number has increased persistently, reaching nearly 480,000 by 2021. Projections estimate that the global number of deaths will exceed 700,000 by 2035, with the ASMR anticipated to rise to approximately 6.7 per 100,000 population (Figure 5C and Table S8).

The global number of DALYs due to CKD from T2DM is also forecasted to continue increasing. From an estimated 11.3 million in 2021, DALYs are expected to reach nearly 15 million by 2035-an increase of over 30%. Concurrently, the ASR is projected to rise steadily from around 130 per 100,000 in 2021 to nearly 200 per 100,000 by 2035 (Figure 5D and Table S8).

Sensitivity analyses restricted to individuals aged 15–89 years yielded forecast patterns similar to those observed in the primary all-age analysis, suggesting that the main projections were robust to differences in age-range specification (Figure S5 Table S9). Rolling-origin back-testing showed generally acceptable predictive accuracy across outcomes, sexes, and metrics, with MAPE values mostly around 1%-3% in the main analysis and similar results in the 15–89 years sensitivity analysis (Tables S10).

Discussion.

DKD is a major clinical contributor to ESKD, and recent epidemiological studies suggest that its share has increased from 22.1% to 31.3% globally [11]. Compared to patients with diabetes alone, those with DKD face substantially higher risks of all-cause mortality and cardiovascular-related death [12]. Beyond its severe impact on public health, CKD attributable to T2DM imposes a considerable health and economic burden worldwide [13]. However, it is important to distinguish clinical DKD from the outcome quantified in this study. Specifically, our analyses estimate the burden of CKD attributable to T2DM under the GBD comparative risk assessment (CRA) framework (a population-attributable, counterfactual construct) rather than clinically diagnosed DKD. Consequently, analyzing CRA-based trends in incidence and DALYs attributable to T2DM-related CKD is crucial for forecasting future burden and informing policy priorities in diabetes and kidney health.

The present study's findings demonstrate significant global increases in incidence, prevalence, mortality, and DALYs attributable to CKD attributable to T2DM (GBD CRA construct) between 1990 and 2021. While age-standardized prevalence and mortality rates exhibited stabilization or decline in some high SDI countries, but rose significantly in low-middle SDI countries. BAPC projections suggest that the burden of prevalence will increase further by 2035, particularly in low- and middle-income regions. Notably, the ASPR demonstrated a consistent downward trajectory, declining from 1,327.22 (1,223.26-1,439.42) to 1,259.63 (1,161.99-1,359.92) per 100,000 population, consistent with the 2019 edition of the GBD data. The results of this study also showed that the decline in ASPR coexisted with a rise in total prevalence, which was associated with population ageing, rising diabetes prevalence over time, and greater ascertainment of diabetes and kidney impairment (e.g., diabetes detection and eGFR/albuminuria testing), rather than implying direct changes in clinically diagnosed DKD alone. Our analyses revealed a consistently elevated disease burden among male populations across nearly all age strata, with particularly pronounced disparities in individuals aged >55 years. This gender disparity likely stems from multiple interrelated factors: higher baseline morbidity rates among males, reduced healthcare-seeking behaviour, poorer treatment adherence, and psychosocial dimensions [14-16]. Another notable finding was the divergence between increasing prevalent case numbers and declining age-standardized prevalence rates in many regions. This pattern is not inconsistent, but rather reflects the different epidemiological meanings of absolute counts and standardized rates. The number of prevalent cases is shaped by demographic expansion, population ageing, and the rising global pool of individuals living with T2DM; as a result, the total burden of CKD attributable to T2DM may continue to grow even when age-standardized prevalence declines. By contrast, ASPR reflects the prevalence burden after removing differences in age composition, and thus may decrease when age-specific risks are reduced through better glycaemic control, blood pressure management, renin–angiotensin system blockade, or wider use of newer kidney-protective therapies. At the same time, improved screening and earlier recognition of kidney dysfunction may increase case detection, while better survival among people with diabetes may expand the number of individuals living with chronic kidney impairment. Therefore, declining ASPR should be interpreted cautiously: it may indicate some improvement in age-adjusted risk, but it does not offset the growing demand placed on health systems by the rising absolute number of people requiring long-term DKD-related care.

The results of the study show that the stabilization or decline in ASDR in high-income countries is associated with the establishment of stronger diabetes and CKD prevention-and-care systems. In contrast, ASMR and ASDR are high but slow-growing in low-SDI countries, and may be associated with underdiagnosis and early deaths. This study shows that the rapidly increasing burden in parts of Asia, especially in South and Southeast Asia and parts of Africa, needs to be of global concern, possibly through upgrading preventive and medical technologies and increasing investment in healthcare resources, which provides a reference and basis for countries to formulate healthcare policies [17].

Given the distinctive epidemiological patterns of CKD burden attributable to T2DM (CRA-based estimates), this study systematically evaluates three key intervention domains for improving prevention efficacy, reducing disease incidence, and alleviating healthcare burdens. It was found that early intervention in diabetes control strategies can slow down the rising trend of CKD attributable to T2DM, strengthen the training of healthcare workers and the education of patients, and the joint intervention of doctors and patients can help to prevent and control kidney complications in people with T2DM [18-20]. In high-burden areas, early screening and standardized treatment-including routine eGFR and albuminuria testing in adults with diabetes and guideline-concordant kidney-protective therapy can also help curb the rising burden of CKD attributable to T2DM [21]. Furthermore, strategic reallocation of medical resources to high-incidence regions, combined with optimization of existing healthcare infrastructure, represents a viable approach for both reducing the attributable CKD burden and mitigating associated economic burdens on healthcare systems [22].

In the context of our finding that deaths and DALYs from CKD attributable to T2DM continue to rise-most steeply across several low- and middle-SDI settings-forward planning should recognize that the global number of people living with diabetes is projected to exceed 1.3 billion by 2035, with particularly high future prevalence in North Africa & Middle East and in Latin America & Caribbean [4]. For low/low-middle SDI regions, the highest return is likely from strengthening primary-care delivery of a cardio-renal bundle-annual eGFR and albuminuria testing in adults with diabetes plus blood-pressure and glycemic control with ACEi/ARB as indicated-implemented through standardized platforms such as WHO HEARTS and WHO PEN [23].

This package is consistent with evidence-based guidance that now prioritizes kidney-protective therapies in T2DM with CKD, including RAS blockade, SGLT2 inhibitors, and-in appropriate patients-GLP-1 receptor agonists [5]. Real-world data show that albuminuria testing remains underused even in high-income systems, reinforcing the need for explicit coverage targets and dashboard monitoring in national diabetes programs [24]. For middle-SDI regions, scaling access to SGLT2 inhibitors for eligible patients can avert CKD progression and cardiovascular events, as demonstrated in EMPA-KIDNEY [7], while GLP-1 receptor agonists such as semaglutide further reduce clinically important kidney outcomes and CV death [8]. In high-middle/high SDI settings, priorities include closing equity gaps in kidney-protective therapies and intensifying early detection to delay dialysis and transplantation—services that remain unevenly available across regions according to the Global Kidney Health Atlas [25]. Although these clinical strategies target CKD in people with diabetes, they are also directly relevant for bending the population-attributable CKD burden estimated under the CRA framework. Finally, because our forecasts extrapolate recent trends rather than encode future structural changes, national and regional planners should pair them with scenario analyses (e.g., expanded albuminuria testing or SGLT2i uptake) to guide workforce, drug procurement, and laboratory capacity over the next decades [4-5].

Building on our SDI- and region-stratified findings, future work should (i) disentangle geographic heterogeneity in CKD attributable to T2DM by linking GBD outputs to comparable indicators of risk exposure (adiposity, hypertension), detection/treatment coverage, and system capacity (nephrology workforce; dialysis and transplant availability), so that differences in ASMR/ASDR across the 21 GBD regions can be mapped to modifiable drivers [24]. (ii) Evaluate real-world implementation and effectiveness of a cardio renal bundle annual albuminuria and eGFR testing, blood-pressure and glycemic control with ACEi/ARB, and use of SGLT2 inhibitors and GLP-1 receptor agonists-given persistent under-testing for albuminuria even in high-income systems and robust trial evidence for kidney–cardiovascular protection [7-8,24]. (iii) Benchmark forecasting methods by comparing our BAPC approach with alternative frameworks-Bayesian APC variants with different priors, spatiotemporal hierarchical/Gaussian-field models, and ensemble or Lee-Carter-type approaches and pair forecasts with policy-relevant scenario analyses that vary screening and therapy coverage to test robustness and decision value [26-27]. Finally, because global diabetes prevalence is projected to exceed ~1.31 billion by 2035, multi-country consortia should build harmonized monitoring pipelines that track annual ASRs, coverage of albuminuria testing and kidney-protective therapies, and outcomes to evaluate whether targeted investments in low- and middle-SDI settings are bending projected trajectories [4].

Our mid-century projections broadly concur with recent short-horizon CKD forecasts in showing rising absolute deaths alongside flat or modestly declining age-standardized mortality at the global level [28]. Where magnitudes or turning points differ, several structural factors explain the divergence: our analysis targets CKD attributable to T2DM under the GBD comparative-risk framework (vs. all-cause CKD in many prior forecasts), and uses the GBD 2021/updated inputs, which revise baseline levels and covariates relative to earlier GBD vintages [29]. Methodologically, we employ a Bayesian age–period–cohort approach with explicit identifiability constraints and integrated-Laplace inference, whereas several short-term exercises use generalized additive models or other smoothing/time-series methods; such model-family differences can shift both level and slope [26,28]. In addition, forecast horizon matters-projections to 2035 (this study) versus 2030 (many prior studies) naturally widen uncertainty and can reveal later inflection points [27]. Finally, cross-study comparisons are sensitive to age-standardization choices (GBD standard population) and age-bin definitions; therefore, we recommend focusing on directionality and ranges rather than exact point estimates when benchmarking across studies [30].

This study has several limitations that should guide interpretation. First, our estimates of CKD attributable to T2DM follow the GBD comparative risk assessment construct and should be interpreted as a standardized counterfactual policy construct, distinct from clinically defined DKD. Second, input data quality varies across regions; where primary data are sparse the GBD framework necessarily borrows strength across time/space, which can widen uncertainty intervals and attenuate contrasts-our sensitivity analyses excluding lowest-data-density locations yielded qualitatively similar patterns, but bias cannot be ruled out. Third, the joint interpretation of ASPR requires caution: declines in ASPR do not automatically indicate lower individual risk because demographic shifts, diagnostic intensity, survivorship, and competing risks may change standardized rates even as counts rise; regions with negative ASPR changes should be triangulated with cohort/registry indicators before inferring reduced progression. Fourth, our forecasts are trend extrapolations from Bayesian age-period-cohort models and remain uncertain at mid-century horizons: despite identifiability constraints (sum-to-zero on deviations and a drift anchor) and rolling-origin back-testing with calibration and error metrics, credible intervals widen in the far future and under alternative reasonable prior smoothness or projection windows; different forecasting frameworks could yield different magnitudes, and our projections do not encode future structural shifts in screening or therapy uptake. Fifth, although all headline results are reported with 95% UIs/CrIs and figures display interval ribbons, our "no clear change/difference" rule (when intervals include the null) may still miss small but real effects in sparse strata; conversely, wide intervals-particularly in older ages-reflect genuine uncertainty. Sixth, the use of the GBD global standard population for age standardization enhances cross-place/time comparability but may mask local age-structure effects; our chosen age bins (including the oldest ages, where competing risks are substantial) balance stability and resolution and could influence presentation of gradients. Finally, policy statements are offered as suggestions/hypotheses rather than prescriptions; we did not conduct cost-effectiveness or budget-impact analyses, and implementation should be contextualized to local resources, equity considerations, and health-system capacity.

Conclusion.

CKD attributable to T2DM has become a substantial global health burden and is projected to continue increasing over the coming years. Future research should further distinguish clinically defined DKD phenotypes from population-level attributable CKD estimates, while strengthening evaluation of intervention effectiveness and optimization of global resource allocation.

Data Sharing Statement.

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding authors.

Ethics Approval and Consent to Participate.

None.

Author Contributions.

The authors Jiaqi Liu and Ying Yu were responsible for the research design. The coauthors Yan Pan and Hanglin Li were responsible for information collection. The coauthors Zuliang Yan and Hong Jiang were responsible for data measurement. The corresponding author, Ying Yu, was responsible for research guidance. All the authors contributed to the article and approved the submitted version.

Disclosure statement.

No potential conflicts of interest were reported by the authors.

Funding.

This work was supported by the Accented Project of Natural Science Research in University of Anhui Province [2023AH051936]; Project of National University Student Innovation Training Program [202310367013].

This work was supported by the present study was funded by the 512 Talent Cultivation Plan of Bengbu Medical College, China (by51201307).

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