Research Letter

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Global clinical trial landscape of stem cell therapy for renal diseases: a 2008–2025 systematic analysis

LuYao Shi, MD[a], WenXing Fan, PhD[a,b,*]

Globally, the prevalence of patients with renal illnesses, encompassing acute kidney injury (AKI), chronic kidney disease (CKD), and kidney failure requiring replacement therapy (KFRT), surpasses 850 million, constituting a significant public health issue[1]. Guideline-directed medical therapy (RAS blockade, SGLT2 inhibitors, non-steroidal mineralocorticoid receptor antagonists (ns-MRAs) such as finerenone, GLP-1 Ras, etc.), the standard treatment for kidney illness, fails to halt the development of most patients to end-stage renal disease, necessitating renal replacement therapy, such as maintenance dialysis or kidney transplantation[2]. Allogeneic transplantation is limited by donor scarcity and the need for lifelong immunosuppression, which highlights the unmet need for regenerative solutions[3]. Over the past decade or so, the beneficial efficacy of mesenchymal stem cells (MSCs) for the treatment of kidney disease has been demonstrated in a variety of cellular and animal experimental models. For example, Yu *et al* showed that human umbilical cord mesenchymal stem cell exosomes (HucMSC-Exos) could attenuate renal tubular epithelial cell injury and enhance repair by regulating necrotic apoptosis through miR-874-3p[4]. Li *et al* showed that hP-MSC-derived extracellular vesicles could be used to treat renal disease by regulating the miR-99b-5p/mTOR/autophagy axis to attenuate renal injury in diabetic kidney disease (DKD)[5]. MSC therapy has become a new treatment for kidney disease by promoting the recovery of renal function after nephropathy through various mechanisms such as anti-inflammatory, anti-apoptotic, angiogenic, anti-oxidative stress, anti-fibrotic, and the modulation of autophagy and senescence.

To facilitate translation of these promising preclinical findings, we systematically evaluated clinical trials of cellular therapies for kidney disease. We queried the Trialtrove database (https://citeline.informa.com/trials/results) with data as of 9 June 2025, using the following search strategy: "Drug Type is Biological > Cellular > Cell type > Stem cell" and "Disease: Renal Disease." A total of 56 eligible human phase I–IV interventional trials from 2008 to 2025 were obtained from this search. Exclusion criteria were: (1) non-interventional/observational studies; (2) pediatric-only populations; (3) duplicate registrations; (4) no stem-cell intervention arm. Multi-arm trials were analyzed using the primary stem-cell arm versus control. Data were extracted on drug name, cell type, trial phase, indication, and relevant trends to assess the global development of cell-based therapies for kidney disease.

An examination of these 56 clinical trials uncovered several significant insights: clinical trials investigating stem cell therapy for renal disease commenced in 2008, and it is significant that the number of trial initiations rose by 20% in 2025 (Table 1 and Figure 1B). 44.6% of trials were in phase I, one phase IV trial was completed (Fig. 1D), and the majority of clinical studies remain in the preliminary phases; regarding functional improvement and clinical indicators, the outcomes of clinical trials are more promising. China conducted 19 trials, representing 33.9% of the global total (Fig. 1A). The investigations mostly included patients with various functional phases of CKD, DKD, and AKI resulting from numerous causes (Fig. 1C). MSCs were the primary intervention in this domain, regarded as the most promising stem cell population for kidney disease treatment, alongside autologous stem cells at 16.1% and BM-MSCs at 17.9% (Table 1 and Figure 1E). At the time of analysis, 14.3% of trials were in the planning phase, while 46.4% had been completed. Six trials yielded positive functional outcomes (Supplemental digital content Table S1, available at: http://links.lww.com/JS9/G345). REGEND-003, a urine-derived renal progenitor cell therapy that exemplifies a noninvasive cell acquisition technology, has commenced a phase I clinical study in China and is demonstrating initial indications of success.

In summary, clinical trials of cell-based therapies for renal diseases are advancing vigorously and expanding. Most remain in early phases, yet results to date are encouraging in terms of functional improvement and clinical indices. Nevertheless, stem-cell therapy faces multiple challenges: inadequate disease control, an unfavorable cellular microenvironment, anoikis, ischemia, inflammation, and excessive reactive oxygen species production.

[a]Department of Nephrology, The First Affiliated Hospital of Kunming Medical University, Kunming, Yunnan Province, China and [b]Yunnan Key Laboratory of Organ Transplantation, The First Affiliated Hospital of Kunming Medical University, Kunming, Yunnan Province, China

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*Corresponding author. Address: Department of Nephrology, The First Affiliated Hospital of Kunming Medical University, No. 295, Xichang Road, Kunming 650032, Yunnan Province, China; Yunnan Key Laboratory of Organ Transplantation, The First Affiliated Hospital of Kunming Medical University, Kunming, Yunnan Province, China. Tel.:+86-15987165447; Fax: +86-087165324888.
E-mail: fanwx2020@163.com (W.X. Fan).

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Table 1

Distribution of Primary Interventions in Cell-Based Therapies for Renal Diseases by Trial Phase

Category and Primary Tested Drug	Phase I (n = 25)	Phase I/II (n = 18)	Phase II (n = 5)	Phase II/III (n = 7)	Phase III (n = 7)
1. Mesenchymal Stem Cell (MSC) Subtypes					
BM-MSCs	3 (12.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
BM-MSCs (Mobcel-M)	0 (0.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
BM-MSCs (SBI-101)	0 (0.0%)	2 (11.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
UC-MSCs	1 (4.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	1 (14.3%)
UC-MSCs (RY_SW_01)	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
AD-MSCs	3 (12.0%)	2 (11.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
AD-MSCs (ADR-01)	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
AD-MSCs (EliCyle)	0 (0.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
MSCs (Unspecified Source)	5 (20.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (14.3%)
MSCs (AC-60 T)	1 (4.0%)	0 (0.0%)	1 (20.0%)	0 (0.0%)	0 (0.0%)
gMSC-I	0 (0.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
ABCB1 + MSCs	0 (0.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
MSC Subtypes Subtotal	**15 (60.0%)**	**10 (55.6%)**	**1 (20.0%)**	**0 (0.0%)**	**2 (28.6%)**
2. Progenitor/Tissue-Specific Cells					
REGEN-003 (Urine-derived Renal Progenitor Cells)	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
VSCs (KDSTEM) (Vascular Stem Cells)	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Progenitor Cells Subtotal	**2 (8.0%)**	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**
3. Hematopoietic/Other Stem Cells					
G-CSF Mobilized CD34 + Cells	1 (4.0%)	3 (16.7%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
R-HSC-010	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Hematopoietic Stem Cells Subtotal	**2 (8.0%)**	**3 (16.7%)**	**0 (0.0%)**	**0 (0.0%)**	**0 (0.0%)**
4. Non-Cellular Drugs (Control/Combination)					
Aminocrocol	0 (0.0%)	0 (0.0%)	2 (40.0%)	0 (0.0%)	0 (0.0%)
ReoGRO Maintenance-L	0 (0.0%)	1 (5.6%)	0 (0.0%)	1 (100.0%)	0 (0.0%)
Non-Cellular Drugs Subtotal	**0 (0.0%)**	**1 (5.6%)**	**2 (40.0%)**	**1 (100.0%)**	**0 (0.0%)**
5. Unclassified/Broad-Spectrum Cell Therapies					
Allogeneic Stem Cells	1 (4.0%)	1 (5.6%)	2 (40.0%)	2 (28.6%)	0 (0.0%)
Allogeneic Stem Cells (KKL-101)	0 (0.0%)	1 (5.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Autologous Stem Cell	4 (16.0%)	2 (11.1%)	0 (0.0%)	1 (14.3%)	0 (0.0%)
ANT-SM	1 (4.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Unclassified Cell Therapies Subtotal	**6 (24.0%)**	**4 (22.2%)**	**2 (40.0%)**	**3 (42.9%)**	**0 (0.0%)**
Total	**25 (100%)**	**18 (100%)**	**5 (100%)**	**7 (100%)**	**7 (100%)**

BM-MSCs: Bone Marrow-derived Mesenchymal Stem Cells.
UC-MSCs: Umbilical Cord-derived Mesenchymal Stem Cells.
AD-MSCs: Adipose-derived Mesenchymal Stem Cells.
VSCs: Vascular Stem Cells.
Percentages are calculated relative to the total number of trials in each respective phase (column total).
Bold values represent the subtotal for each subcategory.

Additional variables – stem-cell source, isolation and purification protocols, and routes of administration – can also influence therapeutic efficacy. Consequently, the safety profile of MSCs must be continually refined through ongoing clinical studies (Supplemental digital content Table S1, available at: http://links.lww.com/JS9/G345). Much work remains before MSCs can be deployed on a large scale in routine clinical practice.

Currently, most points on the therapeutic potential of MSCs primarily focus on discussing existing challenges (such as immune rejection, poor homing ability, etc.) and optimization strategies, systematically reviewing the basic research and clinical applications of MSCs in renal diseases[6,7]. In stark contrast, our study delivers a groundbreaking, data-informed panorama of the global clinical translation landscape for cellular therapies in kidney diseases. Through systematic analysis of 56 clinical trials conducted between 2008 and 2025, we provide the first comprehensive macroscopic overview of this rapidly evolving field. Our work not only quantifies accelerating clinical activity, evidenced by a notable 20% surge in trial initiations in 2025, but also delineates the predominant cellular entities deployed and identifies key disease targets, including CKD, DKD, and AKI. More significantly, we uncover strategically vital developments such as the pivotal role of China, which accounts for 33.9% of global trials, and the emergence of noninvasive cell harvesting methodologies, exemplified by the urine-derived renal progenitor cell therapy REGEND-003, which has demonstrated preliminary clinical success. This analysis thereby bridges a critical gap between theoretical MSC research and tangible clinical progress, offering an evidence-based framework for guiding future therapeutic development and translational investment.

No any AI was used in the research and manuscript development[8].

Ethical approval

Not applicable.

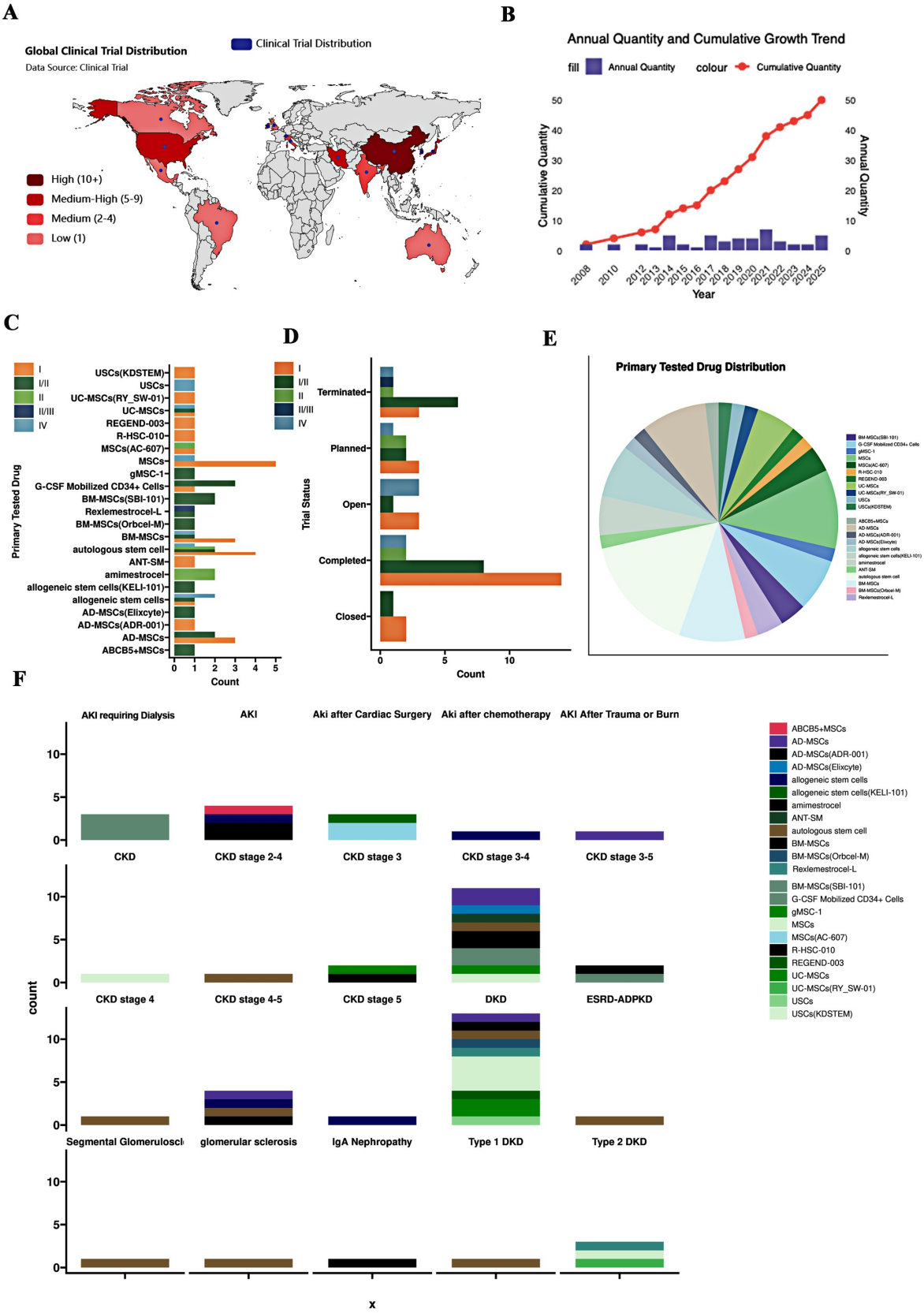

Figure 1. (A) Map of the world distribution of participating countries. (B) Map of cumulative year-to-year trends in cellular therapies. (C) Map of cellular therapy trial phases. (D) Clinical trials of cellular therapies. (E) Pie chart of primary trial drugs. (F) Primary tested drug counts by patient segment.

Consent

Not applicable.

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Author contributions

Not applicable.

Conflicts of interest disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. L.S. and W.F. contributed to the design, production and editing of the manuscript.

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