

Supplementary Table S1. Database-specific search strategies.

Database	Search strategy
Scopus	TITLE-ABS-KEY(("data centre*" OR "data center*" OR datacenter*) AND ("artificial intelligence" OR "machine learning" OR GPU* OR HPC OR "high-performance computing" OR cloud OR "edge-cloud") AND ("grid-interactive" OR "smart grid*" OR "renewable energy" OR "carbon-aware" OR "workload shift*" OR "demand response" OR "ancillary service*" OR "frequency response" OR "energy storage" OR batter* OR UPS OR cooling OR "thermal storage" OR "waste heat" OR "heat recovery" OR "power quality"))
Web of Science	TS(("data centre*" OR "data center*" OR datacenter*) AND ("artificial intelligence" OR "machine learning" OR GPU* OR HPC OR "high-performance computing" OR cloud OR "edge-cloud") AND ("grid-interactive" OR "smart grid*" OR "renewable energy" OR "carbon-aware" OR "workload shift*" OR "demand response" OR "ancillary service*" OR "frequency response" OR "energy storage" OR batter* OR UPS OR cooling OR "thermal storage" OR "waste heat" OR "heat recovery" OR "power quality"))
IEEE Xplore	("data center" OR "data centre" OR datacenter) AND ("artificial intelligence" OR "machine learning" OR GPU OR HPC OR cloud) AND ("smart grid" OR "renewable energy" OR "grid-interactive" OR "carbon-aware" OR "workload shifting" OR "demand response" OR "ancillary services" OR "frequency response" OR "energy storage" OR UPS OR cooling OR "waste heat" OR "power quality")
ACM Digital Library	("data center" OR "data centre" OR datacenter) AND ("artificial intelligence" OR "machine learning" OR GPU OR HPC OR cloud OR "edge-cloud") AND ("renewable energy" OR "carbon-aware" OR "grid-interactive" OR "smart grid" OR "workload shifting" OR "demand response" OR "energy storage" OR UPS OR cooling OR "waste heat")
ScienceDirect	("data center" OR "data centre" OR datacenter) AND ("artificial intelligence" OR "machine learning" OR GPU OR HPC OR cloud) AND ("renewable energy" OR "carbon-aware" OR "smart grid" OR "demand response" OR "workload shifting" OR "energy storage" OR UPS OR cooling OR "thermal storage" OR "waste heat" OR "power quality")
SpringerLink	("data center" OR "data centre" OR datacenter) AND ("artificial intelligence" OR "machine learning" OR GPU OR HPC OR cloud) AND ("renewable energy" OR "carbon-aware" OR "smart grid" OR "demand response" OR "workload shifting" OR "energy storage" OR UPS OR cooling OR "waste heat")
Google Scholar	Supplementary combinations included "AI data center" "grid flexibility", "AI data centre" "renewable energy", "data center" "carbon-aware" workload, "data center" "demand response", "data center" UPS "frequency response", "data center" "waste heat" and "data center" "power quality" UPS.

Supplementary Table S2. Eligibility criteria applied during full-text assessment.

Inclusion criteria	Exclusion criteria
Published from 2022 to 2026	Published before 2022
Data-centre, AI / GPU, HPC, cloud or edge-cloud context	Unrelated residential, commercial or industrial energy systems
Renewable energy, carbon-aware computing, smart-grid participation, demand response, storage or grid-service relevance	Computing performance or generic energy efficiency without a relevant grid, carbon or renewable-energy dimension
Experimental, empirical, field, trace-based, modelling, optimisation or relevant review evidence	Editorials, commentaries, news articles and unsupported opinion pieces
Sufficient methodological and outcome information	Inaccessible or methodologically insufficient publications
English-language publication	Non-English publication
Relevant technical, environmental, economic, grid or computing outcomes	Duplicate reports presenting no additional evidence

Note. The retained review materials do not contain a study-level full-text exclusion log from which category-specific exclusion counts can be independently verified. Accordingly, unverified category-level exclusion counts are not reported.

Supplementary Table S3. Characteristics of the 43 included studies.**Part A.** Study context, design, validation and geography.

Study	AI specificity	Evidence context	Study design / methodology	Validation	Geographic / grid context
Acun et al. (2023)	General data-centre transferable evidence	General data centre	Framework and modelling	Level III	Multi-site/not location-specific
Asadov et al. (2025)	Cloud/edge-cloud transferable evidence	Edge-cloud	Review and algorithmic evaluation	Level III	Geo-distributed
Bahreini et al. (2023)	Cloud/edge-cloud transferable evidence	Cloud	Scheduling algorithm/simulation	Level III	Not location-specific
Caprara et al. (2026)	AI/GPU-specific	AI/ML and GPU-related	Operational-trace analysis and optimisation	Level II	Alibaba production traces
Chen et al. (2023)	General data-centre transferable evidence	General data centre	Experimental	Level II	Laboratory setting
Chen et al. (2025)	Cloud/edge-cloud transferable evidence	Geo-distributed cloud/data centre	Online optimisation	Level III	Multi-region
Chen and Zheng (2026)	AI/GPU-specific	AI data centre	Grid-planning optimisation	Level III	Multi-location grid scenarios
Colangelo et al. (2025)	AI/GPU-specific	AI/GPU-specific	Field demonstration	Level I	Phoenix, Arizona, USA
Crozier and Liska (2025)	General data-centre transferable evidence	General data centre	Review/perspective	Level IV	International
Cui et al. (2024)	General data-centre transferable evidence	General data centre	Laboratory experiment	Level II	Laboratory setting
Dinesh Reddy et al. (2024)	General data-centre transferable evidence	General data centre	Optimisation/simulation	Level III	Not location-specific
Hao et al. (2025)	General data-centre transferable evidence	General data centre	Review	Level IV	International
Hewage et al. (2025)	Cloud/edge-cloud transferable evidence	Edge/cloud	Optimisation/simulation	Level III	Geo-distributed
Hussain et al. (2024)	Cloud/edge-cloud transferable evidence	Cloud	Workflow optimisation/simulation	Level III	Geo-distributed
Khodayarsersht et al. (2023)	Cloud/edge-cloud transferable evidence	Cloud	VM-placement optimisation	Level III	Geo-distributed
Lin et al. (2022)	General data-centre transferable evidence	General data centre	Thermodynamic modelling	Level III	Not location-specific
Miao et al. (2024)	AI/GPU-specific	AI/DML-specific edge-cloud	Scheduling optimisation	Level III	Dallas, Elizabeth City and Boston
Nkwawir et al. (2025)	General data-centre transferable evidence	General data centre	Multi-energy optimisation	Level III	Not location-specific
Paananen (2023)	General data-centre transferable evidence	General data centre	Technical perspective	Level IV	International
Piontek et al. (2024)	Cloud/edge-cloud transferable evidence	Cloud/Kubernetes	Implemented experimental scheduling	Level II	German/European carbon-intensity scenarios
Radovanović et al. (2023)	General data-centre transferable evidence	Hyperscale data centre	Production-system evaluation	Level I	Google's multi-regional fleet
Ruparel (2026)	Cloud/edge-cloud transferable evidence	Cloud	Robust optimisation	Level III	Not location-specific

Senga et al. (2026)	General data-centre transferable evidence	General data centre with AI-demand context	Capacity-expansion modelling	Level III	Texas, Mid-Atlantic and WECC, USA
Shim (2025)	HPC transferable evidence	HPC	Empirical trace/data analysis	Level II	PM100 HPC dataset
Sun et al. (2022a)	General data-centre transferable evidence	General data centre	Electrical modelling	Level III	Not location-specific
Sun et al. (2022b)	General data-centre transferable evidence	General data centre	System modelling	Level III	Not location-specific
Sutaria and Rönnberg (2023)	General data-centre transferable evidence	General data centre	Measurement/experimental analysis	Level II	Data-centre installation
Takci et al. (2025)	General data-centre transferable evidence	General data centre	Review/synthesis	Level IV	International
Tao and Gadh (2025)	General data-centre transferable evidence	General data centre	Dynamic grid simulation	Level III	Modified IEEE 39-bus system
Verma et al. (2024)	Cloud/edge-cloud transferable evidence	Cloud	Survey	Level IV	International
Williams et al. (2026)	AI/GPU-specific	AI/GPU-specific	Operational/field demonstration	Level I	Real-world GPU cluster
Xu et al. (2023)	General data-centre transferable evidence	General data centre	Multi-energy optimisation	Level III	Southwest China
Ye et al. (2023)	General data-centre transferable evidence	General data centre	Optimisation/simulation	Level III	Geo-distributed
Yuan et al. (2023)	General data-centre transferable evidence	General data centre	Review	Level IV	International
Zhang et al. (2025a)	General data-centre transferable evidence	General data centre	Storage design/optimisation	Level III	Not location-specific
Zhang et al. (2024)	General data-centre transferable evidence	General data centre	Optimisation and event-based simulation	Level III	Multi-data-centre/aggregator
Zhang et al. (2025b)	General data-centre transferable evidence	General data centre	Integrated network optimisation	Level III	Power-traffic-data network model
Zhao and Zhou (2022)	Cloud/edge-cloud transferable evidence	Cloud	Scheduling optimisation	Level III	Distributed cloud
Zhao et al. (2023)	General data-centre transferable evidence	General/geo-distributed data centre	Optimisation	Level III	Geo-distributed
Zhou et al. (2025a)	General data-centre transferable evidence	General data centre	Validated dynamic modelling	Level III	Beijing, China
Zhou et al. (2024a)	General data-centre transferable evidence	General data centre	Optimisation/simulation	Level III	Geo-distributed
Zhou et al. (2024b)	AI/GPU-specific	AI/GPU-specific HPC	Real workload-trace analysis	Level II	Fourteen AI/general HPC data centres
Zhou et al. (2025b)	General data-centre transferable evidence	General data centre	Load modelling/optimisation	Level III	Not location-specific

Part B. Workload, energy context, mechanisms, outcomes and limitations.

Study	Workload / technology context	Renewable / energy context	Flexibility mechanism / principal outcome	Performance indicator / reported result	Main evidence limitation
Acun et al. (2023)	Flexible computing workload	Carbon intensity and/or renewable-energy coordination	Joint hardware, renewables, workload and lifecycle carbon	Joint hardware, renewables, workload and lifecycle carbon	Model-dependent assumptions
Asadov et al. (2025)	Cloud/VM/container /workflow workloads	Carbon intensity and/or renewable-energy coordination	Spatio-temporal carbon-aware shifting	Spatio-temporal carbon-aware shifting	Limited operational validation
Bahreini et al. (2023)	Cloud/VM/container /workflow workloads	Carbon intensity and/or renewable-energy coordination	Carbon-aware workload dispatch	Carbon-aware workload dispatch	Simulation-based
Caprara et al. (2026)	AI/ML/GPU workloads or AI-oriented infrastructure	Grid-service/demand-response context	Workload deferral and demand response	>20% of estimated GPU-side power associated with deferrable tasks; up to 22% load shedding.	Trace-to-power modelling required
Chen et al. (2023)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Cooling and waste-heat recovery	Cooling and waste-heat recovery	Component/facility-scale evidence
Chen et al. (2025)	Cloud/VM/container /workflow workloads	Carbon intensity and/or renewable-energy coordination	Carbon-aware backup and scheduling	Carbon-aware backup and scheduling	Model-based grid representation
Chen and Zheng (2026)	AI/ML/GPU workloads or AI-oriented infrastructure	Energy/grid context reported qualitatively in the manuscript	Temporal deferral and geographic shifting	Approximately 3-21% reduction in grid investment and operating costs depending on location and flexibility.	Planning-model assumptions
Colangelo et al. (2025)	AI/ML/GPU workloads or AI-oriented infrastructure	Energy/grid context reported qualitatively in the manuscript	Software-controlled power flexibility	25% cluster-power reduction for 3 h on 256 GPUs.	Single operational deployment
Crozier and Liska (2025)	Flexible computing workload	Grid-service/demand-response context	Grid-flexibility mechanisms	Grid-flexibility mechanisms	Secondary evidence
Cui et al. (2024)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Waste-heat-driven adsorption cooling	Coefficient of performance 0.37; specific cooling power 102.35 W/kg.	Component-level validation
Dinesh Reddy et al. (2024)	Flexible computing workload	Energy/grid context reported qualitatively in the manuscript	Resource consolidation and migration	Resource consolidation and migration	Simulation-based
Hao et al. (2025)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Waste-heat recovery technologies	Waste-heat recovery technologies	Secondary evidence
Hewage et al. (2025)	Cloud/VM/container /workflow workloads	Energy/grid context reported qualitatively in the manuscript	Spatio-temporal workload shifting	Spatio-temporal workload shifting	Migration assumptions
Hussain et al. (2024)	Cloud/VM/container /workflow workloads	Energy/grid context reported qualitatively in the manuscript	Price- and energy-aware scheduling	Price- and energy-aware scheduling	Simulated workloads/grid signals
Khodayarsersht et al. (2023)	Cloud/VM/container /workflow workloads	Carbon intensity and/or renewable-energy coordination	Carbon- and energy-aware placement	Carbon- and energy-aware placement	Limited field validation
Lin et al. (2022)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Heat pump and absorption refrigeration	Heat pump and absorption refrigeration	Model-level validation

Miao et al. (2024)	AI/ML/GPU workloads or AI-oriented infrastructure	Carbon intensity and/or renewable-energy coordination	Multi-renewable DML scheduling	Renewable-energy utilisation 90.8%; average response time 12.6 ms; task-failure rate 1.25%.	Modelled infrastructure
Nkwawir et al. (2025)	Not explicitly specified in the manuscript	Carbon intensity and/or renewable-energy coordination	Carbon-aware multi-energy operation	Carbon-aware multi-energy operation	Simulation-based
Paananen (2023)	Facility electrical load/UPS/converter operation	Electrical storage/UPS and grid interaction	UPS-based grid services	UPS-based grid services	Limited primary experimental evidence
Piontek et al. (2024)	Cloud/VM/container/workflow workloads	Carbon intensity and/or renewable-energy coordination	Temporal carbon-aware job shifting	CO ₂ reduction 0.37-2.41% (~1.3% average) while maintaining service-level requirements.	Small-scale Kubernetes evaluation
Radovanović et al. (2023)	Not explicitly specified in the manuscript	Carbon intensity and/or renewable-energy coordination	Carbon-intelligent temporal shifting	Carbon-intelligent temporal shifting	Proprietary operational environment
Ruparel (2026)	Cloud/VM/container/workflow workloads	Electrical storage/UPS and grid interaction	Forecasting and battery scheduling	Forecasting and battery scheduling	Simulation/model dependence
Senga et al. (2026)	Flexible computing workload	Energy/grid context reported qualitatively in the manuscript	Temporal flexibility, cost and emissions	System cost reductions up to ~4% Mid-Atlantic, 5% Texas and 2% WECC; emissions effects varied by generation mix.	Results sensitive to generation mix
Shim (2025)	HPC jobs/workload traces	Carbon intensity and/or renewable-energy coordination	Job-level carbon-efficiency estimation	Job-level carbon-efficiency estimation	HPC rather than AI-specific
Sun et al. (2022a)	Facility electrical load/UPS/converter operation	Power quality and electrical-interface context	Power-supply impedance	Power-supply impedance	Model/component transferability
Sun et al. (2022b)	Facility electrical load/UPS/converter operation	Power quality and electrical-interface context	Converter and network stability	Converter and network stability	Limited operational grid validation
Sutaria and Rönnberg (2023)	Facility electrical load/UPS/converter operation	Power quality and electrical-interface context	Supraharmonic propagation	Supraharmonic propagation	Facility-specific electrical conditions
Takci et al. (2025)	Flexible computing workload	Energy/grid context reported qualitatively in the manuscript	Power-system flexibility	Power-system flexibility	Secondary evidence
Tao and Gadh (2025)	Facility electrical load/UPS/converter operation	Electrical storage/UPS and grid interaction	Workload and UPS frequency response	Coordinated workload/UPS control improved frequency nadir and recovery in an IEEE 39-bus simulation.	Test-system rather than field validation
Verma et al. (2024)	Cloud/VM/container/workflow workloads	Energy/grid context reported qualitatively in the manuscript	Energy-efficient workflow scheduling	Energy-efficient workflow scheduling	Secondary evidence
Williams et al. (2026)	AI/ML/GPU workloads or AI-oriented infrastructure	Grid-service/demand-response context	Grid-responsive compute orchestration	Grid-responsive compute orchestration	Limited number of deployments
Xu et al. (2023)	Not explicitly specified in the manuscript	Carbon intensity and/or renewable-energy coordination	Renewable portfolio and demand response	Up to 17.8% portfolio-cost reduction in the reported southwest China case.	Regional model assumptions
Ye et al. (2023)	Facility electrical load/UPS/converter operation	Electrical storage/UPS and grid interaction	Workload and UPS coordination	Approximately 5% UPS losses materially affected optimal schedules.	Battery/UPS model dependence
Yuan et al. (2023)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Waste-heat recovery	Waste-heat recovery	Secondary evidence

Zhang et al. (2025a)	Not explicitly specified in the manuscript	Electrical storage/UPS and grid interaction	Energy-storage dispatch and grid services	Energy-storage dispatch and grid services	Simulation-based
Zhang et al. (2024)	Flexible computing workload	Grid-service/demand-response context	Demand response and workload sharing	~5% average data-centre energy-cost reduction; >30% social-cost reduction in most cases; ~6% greater power reduction.	Simulated market environment
Zhang et al. (2025b)	Flexible computing workload	Grid-service/demand-response context	Workload migration and grid-stress reduction	Workload migration and grid-stress reduction	Model complexity and assumptions
Zhao and Zhou (2022)	Cloud/VM/container/workflow workloads	Carbon intensity and/or renewable-energy coordination	Renewable-aware task placement	Renewable-aware task placement	Simulation-based
Zhao et al. (2023)	Flexible computing workload	Grid-service/demand-response context	Workload, energy and demand response	Workload, energy and demand response	Forecast and market assumptions
Zhou et al. (2025a)	Facility cooling/thermal load	Thermal energy, cooling and/or waste-heat recovery	Heat pump, free cooling and heat recovery	Heat pump, free cooling and heat recovery	Case-specific thermal model
Zhou et al. (2024a)	Not explicitly specified in the manuscript	Energy/grid context reported qualitatively in the manuscript	Energy-aware coordinated operation	Energy-aware coordinated operation	Simulation-based
Zhou et al. (2024b)	AI/ML/GPU workloads or AI-oriented infrastructure	Grid-service/demand-response context	Grid flexibility and opportunity cost	Approximately 50% lower flexibility cost than general-purpose HPC.	Trace-based rather than live grid response
Zhou et al. (2025b)	Not explicitly specified in the manuscript	Energy/grid context reported qualitatively in the manuscript	Energy efficiency and demand-response quality	Energy efficiency and demand-response quality	Model-based validation

Note. The table reproduces the 43-study characteristics available in the revised manuscript and expands the coding into the fields described in Section 3.5. Workload and energy-context labels are conservative classifications derived from the manuscript’s own evidence context, study design, mechanism and reported outcomes; fields not directly reported are not invented.

Supplementary Table S4. Study design and operational validation level of the 43 included studies.

Study	Study design / methodology	Validation level
Acun et al. (2023)	Framework and modelling	Level III
Asadov et al. (2025)	Review and algorithmic evaluation	Level III
Bahreini et al. (2023)	Scheduling algorithm/simulation	Level III
Caprara et al. (2026)	Operational-trace analysis and optimisation	Level II
Chen et al. (2023)	Experimental	Level II
Chen et al. (2025)	Online optimisation	Level III
Chen and Zheng (2026)	Grid-planning optimisation	Level III
Colangelo et al. (2025)	Field demonstration	Level I
Crozier and Liska (2025)	Review/perspective	Level IV
Cui et al. (2024)	Laboratory experiment	Level II
Dinesh Reddy et al. (2024)	Optimisation/simulation	Level III
Hao et al. (2025)	Review	Level IV
Hewage et al. (2025)	Optimisation/simulation	Level III
Hussain et al. (2024)	Workflow optimisation/simulation	Level III
Khodayarsersht et al. (2023)	VM-placement optimisation	Level III
Lin et al. (2022)	Thermodynamic modelling	Level III
Miao et al. (2024)	Scheduling optimisation	Level III
Nkwawir et al. (2025)	Multi-energy optimisation	Level III
Paananen (2023)	Technical perspective	Level IV
Piontek et al. (2024)	Implemented experimental scheduling	Level II
Radovanović et al. (2023)	Production-system evaluation	Level I
Ruparel (2026)	Robust optimisation	Level III
Senga et al. (2026)	Capacity-expansion modelling	Level III
Shim (2025)	Empirical trace/data analysis	Level II
Sun et al. (2022a)	Electrical modelling	Level III
Sun et al. (2022b)	System modelling	Level III
Sutaria and Rönnerberg (2023)	Measurement/experimental analysis	Level II
Takci et al. (2025)	Review/synthesis	Level IV
Tao and Gadh (2025)	Dynamic grid simulation	Level III
Verma et al. (2024)	Survey	Level IV
Williams et al. (2026)	Operational/field demonstration	Level I
Xu et al. (2023)	Multi-energy optimisation	Level III
Ye et al. (2023)	Optimisation/simulation	Level III
Yuan et al. (2023)	Review	Level IV
Zhang et al. (2025a)	Storage design/optimisation	Level III
Zhang et al. (2024)	Optimisation and event-based simulation	Level III
Zhang et al. (2025b)	Integrated network optimisation	Level III
Zhao and Zhou (2022)	Scheduling optimisation	Level III
Zhao et al. (2023)	Optimisation	Level III
Zhou et al. (2025a)	Validated dynamic modelling	Level III
Zhou et al. (2024a)	Optimisation/simulation	Level III
Zhou et al. (2024b)	Real workload-trace analysis	Level II
Zhou et al. (2025b)	Load modelling/optimisation	Level III

Supplementary File S5. PRISMA 2020 checklist mapping.

Item	Topic	PRISMA 2020 requirement	Location in revised manuscript	Status / note
1	Title	Identify the report as a systematic review.	Title	Reported
2	Abstract	Provide a structured summary of the review question, methods, results and conclusions.	Abstract	Reported
3	Rationale	Explain the rationale for the review in the context of existing knowledge.	Introduction; Section 2.1	Reported
4	Objectives	State the review objectives/questions explicitly.	Introduction; Section 3.1	Reported
5	Eligibility criteria	Specify inclusion/exclusion criteria and grouping for synthesis.	Section 3.3	Reported
6	Information sources	List databases/sources and the search period/date.	Section 3.2	Partial: sources and period reported; exact final search date is not stated
7	Search strategy	Present the full search strategy for each source, including limits.	Section 3.2; Supplementary Table S1	Reported
8	Selection process	Describe how records/reports were screened and selected.	Section 3.4	Reported, but reviewer-level independence/adjudication is not explicitly documented
9	Data collection process	Describe how data were extracted and checked.	Section 3.5	Reported at framework level
10a	Data items: outcomes	Define outcomes sought from each study.	Section 3.5	Reported
10b	Data items: other variables	Define other extracted variables and assumptions.	Section 3.5	Reported
11	Study appraisal and operational validation	Describe how study appraisal was undertaken, including study design, reported limitations and operational validation context.	Section 3.6; Supplementary Table S4	Study design, assumptions, limitations and operational validation level described; no numerical study-level quality score was used.
12	Effect measures	Specify effect measures for quantitative outcomes when applicable.	Sections 3.5 and 3.7	Not applicable as a pooled meta-analysis was not performed; study-level measures retained
13a	Synthesis eligibility	Describe how studies were assigned to each synthesis.	Sections 3.5 and 3.7	Reported
13b	Data preparation	Describe preparation/handling of data for synthesis.	Section 3.7	Reported
13c	Presentation methods	Describe tabulation/visualisation methods.	Sections 3.7 and 4	Reported
13d	Synthesis methods	Describe the methods used to synthesise results and justify them.	Sections 3.1 and 3.7	Reported
13e	Heterogeneity exploration	Describe methods used to explore causes of heterogeneity.	Sections 3.1 and 3.7	Narrative comparison reported; no statistical heterogeneity analysis
13f	Sensitivity analyses	Describe sensitivity analyses, if performed.	Section 3.7	Not performed at review level
14	Reporting-bias assessment	Describe methods used to assess bias from missing results.	Sections 3.8 and 6	Qualitatively discussed; no formal statistical assessment
15	Certainty / confidence	Describe methods used to judge certainty or confidence in the evidence.	Section 3.7	Reported as qualitative evidence-strength framework
16a	Study selection results	Report the flow from identification through inclusion.	Section 3.4	The final inclusion of 43 studies is confirmed. Unverified intermediate identification and screening counts are not reported.

Item	Topic	PRISMA 2020 requirement	Location in revised manuscript	Status / note
16b	Excluded reports	Cite apparently eligible excluded reports and explain reasons.	Section 3.4; Supplementary Table S2	Study-level full-text exclusion records are unavailable and are not reported. Supplementary Table S2 provides the applied eligibility criteria; unverified category counts are omitted.
17	Study characteristics	Present characteristics of included studies.	Table 2; Supplementary Table S3	Reported
18	Study appraisal and validation results	Report the appraisal information available for individual studies, including study design and operational validation level; identify any limitations concerning formal risk-of-bias assessment.	Section 3.6; Supplementary Table S4	Study design and operational validation level reported for all 43 studies; formal study-level risk-of-bias ratings were not available.
19	Individual-study results	Present relevant results for individual studies.	Sections 4.2-4.5; Tables 2-5; Supplementary Table S3	Reported
20a	Synthesis results: contributing studies	Summarise the characteristics, study design and operational validation level of studies contributing to each synthesis.	Sections 4.1-4.5; Supplementary Tables S3-S4	Study characteristics, study design and operational validation levels are synthesised; numerical study-level quality scores are not used.
20b	Statistical synthesis	Present pooled estimates and heterogeneity when meta-analysis is performed.	Section 3.1; Section 4.4	Not applicable: meta-analysis was not performed
20c	Heterogeneity investigation	Present results of investigations of heterogeneity, if performed.	Sections 4 and 5	Narrative/contextual analysis reported
20d	Sensitivity analysis results	Present sensitivity-analysis results, if performed.	—	Not applicable at review level
21	Reporting-bias results	Present assessments of bias due to missing results.	Sections 3.8 and 6	Qualitative discussion only
22	Certainty of evidence	Present certainty/confidence judgments for major outcomes.	Sections 3.7, 4.5 and 7	Reported qualitatively by validation/evidence strength
23a	Discussion: interpretation	Interpret results in relation to other evidence.	Section 5	Reported
23b	Discussion: evidence limitations	Discuss limitations of the included evidence.	Sections 4.5, 5.4 and 6	Reported
23c	Discussion: review-process limitations	Discuss limitations of the review process.	Section 6	Reported
23d	Discussion: implications	Discuss implications for practice/policy/research.	Sections 5.5, 6 and 7	Reported
24a	Registration	Provide registration information, or state that the review was not registered.	Section 3.1	Reported: not registered
24b	Protocol	Indicate where the protocol can be accessed, or state if none is available.	Section 3.1	Protocol described; no external protocol link/registry reported
24c	Amendments	Describe amendments to registered/protocol methods, if applicable.	—	Not applicable / not reported
25	Support	Describe financial or non-financial support.	Funding	Reported
26	Competing interests	Declare competing interests.	Conflict of Interest	Reported
27	Availability of data/materials/code	State availability of extraction forms, data, analysis code and related materials.	Data Availability Statement; Supplementary Materials	Reported at a general level

Note. This mapping identifies the reported manuscript locations and remaining documentation limitations. The final inclusion of 43 studies is confirmed; unverified intermediate screening counts and study-level full-text exclusion records are not reported. Study design and operational validation levels are reported in Supplementary Table S4.