European Journal of Public Health, 2026, **36**(5), ckag177
https://doi.org/10.1093/eurpub/ckag177
Original Manuscript

Digital health and rural health workforce retention: mapping workforce retention pathways

Tiago Correia[1,2,*], Tomas Zapata[3], Sulakshana Nandi[3], David Novillo-Ortiz[3], James Buchan[4], Shirin Kiani[3], Cathal Morgan[3], Margrieta Langins[3], Anabela da Conceição Pereira[1,2,5], André Beja[1,2], Roberto Esteves[2], Rita Morais[1,2], Mélanie Maia[1,2]

[1]Global Health and Tropical Medicine (GHTM), LA-REAL, Instituto de Higiene e Medicina Tropical (IHMT), Universidade NOVA de Lisboa, Lisboa, Portugal
[2]WHO Collaborating Centre on Health Workforce Policies and Planning, Instituto de Higiene e Medicina Tropical (IHMT), NOVA University Lisbon, Lisbon, Portugal
[3]WHO Regional Office for Europe, Copenhagen, Denmark
[4]WHO Collaborating Centre for Nursing, Midwifery and Health Development, University of Technology, Sydney, Australia
[5]Cies-Iscte, Instituto Universitário de Lisboa, Lisbon, Portugal
*Corresponding author. Global Health and Tropical Medicine (GHTM), LA-REAL, Instituto de Higiene e Medicina Tropical (IHMT), Universidade NOVA de Lisboa, Rua da Junqueira 100, 1349-008 Lisbon, Portugal. E-mail: tiago.correia@ihmt.unl.pt.

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

Abstract

Digital health is increasingly promoted to address rural health and care workforce shortages. However, its workforce consequences are usually evaluated through implementation or service-delivery outcomes rather than the conditions that enable rural workers to remain, develop, and practice sustainably. We conducted a Joanna Briggs Institute-informed scoping review reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews. The protocol was prospectively registered on the Open Science Framework. Five databases were searched for studies published between 2015 and 2025 in English, Spanish, and Portuguese. Two reviewers independently screened records and charted data using a prespecified framework. Synthesized entries were verified against full texts, with disagreements resolved by a third reviewer. Fifty-five sources were included. Telehealth or telemedicine was the most common intervention, followed by tele-education or distance education and multicomponent interventions. Direct retention or workforce-stability outcomes were uncommon, whereas most outcomes concerned proximal determinants of retention or implementation-related sustainability. Digital interventions most frequently influenced professional connection, supervision, continuing education, clinical confidence, and workflow support. Interpretive synthesis identified four workforce redistribution pathways (labor, authority, dependency, and infrastructure risk) through which interventions may strengthen or undermine rural workforce sustainability. Current evidence concerns retention pathways more than retention effects. Digital health should therefore be evaluated as a sociotechnical workforce intervention, extending beyond implementation success to examine how interventions redistribute labor, authority, dependency, and infrastructure risk across rural health systems.

Introduction

Health systems face a persistent health and care workforce crisis, with shortages, maldistribution, burnout, and attrition threatening the sustainability of essential services [1–3]. These pressures are particularly acute in rural, remote, and underserved areas, where smaller teams, broader scopes of practice, geographical isolation, and limited access to specialist support create persistent recruitment and retention challenges [4]. International guidance consistently shows that no single intervention is sufficient; sustainable rural workforce policies combine education, regulation, incentives, professional support, and broader health-system measures [5, 6].

For this review, retention refers to observed continuation in post or workforce stability. Intentions to stay or leave are treated as intermediate outcomes, while professional and organizational conditions, including job satisfaction, burnout, workload, professional isolation, supervision, continuing education, organizational support, autonomy, and the perceived viability of rural practice [7, 8] Workforce sustainability is used as the broader concept, encompassing the conditions required to maintain workforce capacity, distribution, development, and service delivery over time, of which retention is one component.

Digital health has become an integrated component of contemporary health systems. Through interventions such as tele-health, tele-education, digital supervision, clinical

© The Author(s) 2026. Published by Oxford University Press on behalf of the European Public Health Association.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com.

decision-support, electronic information systems, remote monitoring, workforce-management tools, and AI-enabled functionalities, it increasingly shapes how rural services are organized and delivered [9]. These interventions may reduce professional isolation, expand access to specialist expertise, and strengthen learning opportunities, but they may also increase administrative workload, intensify surveillance, reinforce dependence on fragile infrastructure, transfer coordination tasks to local staff, and reshape professional authority between rural and urban services [10]. Consistent with sociotechnical perspectives, digital technologies are therefore understood not as isolated artefacts but as interventions that reshape work organization, professional relationships, and institutional arrangements [11].

The key question is not simply whether digital interventions are implemented or accepted, but whether they strengthen the conditions that make rural practice sustainable. A telehealth network may reduce professional isolation while increasing documentation burden; specialist support may improve clinical confidence while increasing dependence on urban hubs; remote monitoring may extend clinical reach while transferring coordination work to frontline staff. Understanding these trade-offs requires attention to how digital interventions redistribute labor, authority, dependency, and implementation risk across rural, remote, and underserved areas.

This scoping review maps and characterizes the evidence on digital interventions used in rural, remote and underserved settings in relation to health and care worker retention. Specifically, it examines the interventions and implementation approaches evaluated, the retention-related outcomes reported, the mechanisms proposed to explain these outcomes, the implementation conditions influencing sustainability, and the equity issues and unintended consequences identified across the literature. Rather than treating digital health solely as a service-delivery technology, the review examines it through a sociotechnical workforce lens and develops an interpretive framework describing how digital interventions redistribute labor, authority, dependency, and infrastructure risk in ways that may strengthen or undermine rural workforce sustainability.

Methods

Design and protocol

This scoping review followed the Joanna Briggs Institute (JBI) methodology and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [12–15]. The protocol was developed *a priori*, and registered on the Open Science Framework before database searching commenced [16].

Eligibility criteria

Eligibility criteria followed the Population-Concept-Context framework. The population comprised health and care workers practicing in rural, remote or underserved settings, including physicians, nurses, midwives, community health workers, allied health professionals, rehabilitation professionals, and other health or social care workers. Studies involving managers, program staff, or implementation stakeholders were eligible when relevant to workforce or implementation outcomes.

The concept encompassed digital interventions supporting health and care workers or their work in rural, remote or underserved settings, including telehealth or telemedicine, teleeducation, digital supervision or mentoring, electronic health records, health information systems, clinical decision-support, remote monitoring, workforce-management tools, and AI-enabled functionalities embedded within these interventions.

The context included rural, remote or underserved health-service settings in any country, as defined by study authors. Mixed urban–rural studies were included when rural findings were reported separately or represented most of the sample.

Eligible sources included peer-reviewed quantitative, qualitative, and mixed-methods studies, program evaluations, and evidence syntheses reporting at least one retention-related or workforce-sustainability outcome. Editorials, conference abstracts, opinion papers, and technical descriptions without implementation or evaluation were excluded [16].

Information sources and search strategy

MEDLINE (PubMed), Embase/Ovid, CINAHL, Scopus, and LILACS were searched for studies published between January 2015 and December 2025 in English, Spanish or Portuguese. Searches were undertaken between March and April 2026.

Search strategies combined controlled vocabulary and free-text terms relating to four concepts: health and care workers; rural, remote or underserved settings; retention or workforce sustainability; and digital interventions. Database-specific syntax and search strategies are provided in the registered protocol [16].

Selection of sources

Records were imported into Rayyan. Duplicate records were removed before Rayyan's AI-assisted screening functionality was used to identify records likely to be ineligible. These records were reviewed and confirmed by one reviewer before the remaining records underwent independent title and abstract screening by two reviewers. Disagreements were resolved through discussion and, where necessary, consultation with a third reviewer. Across all databases, 10 547 records were identified. After removing 4451 duplicates and confirming 2098 AI-flagged ineligible records, 3998 records underwent title and abstract screening. Of these, 151 full texts were sought and 138 assessed for eligibility. Fifty-five studies met the inclusion criteria (Fig. 1).

Data charting

A structured data-charting framework derived from the protocol objectives was piloted before extraction. Two reviewers independently charted study characteristics, intervention features, outcomes, mechanisms, implementation conditions, equity issues, and evidence gaps. All charted entries included in the synthesis were verified against the corresponding full texts before normalization and analysis. Uncertainties were resolved through discussion with a third reviewer.

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

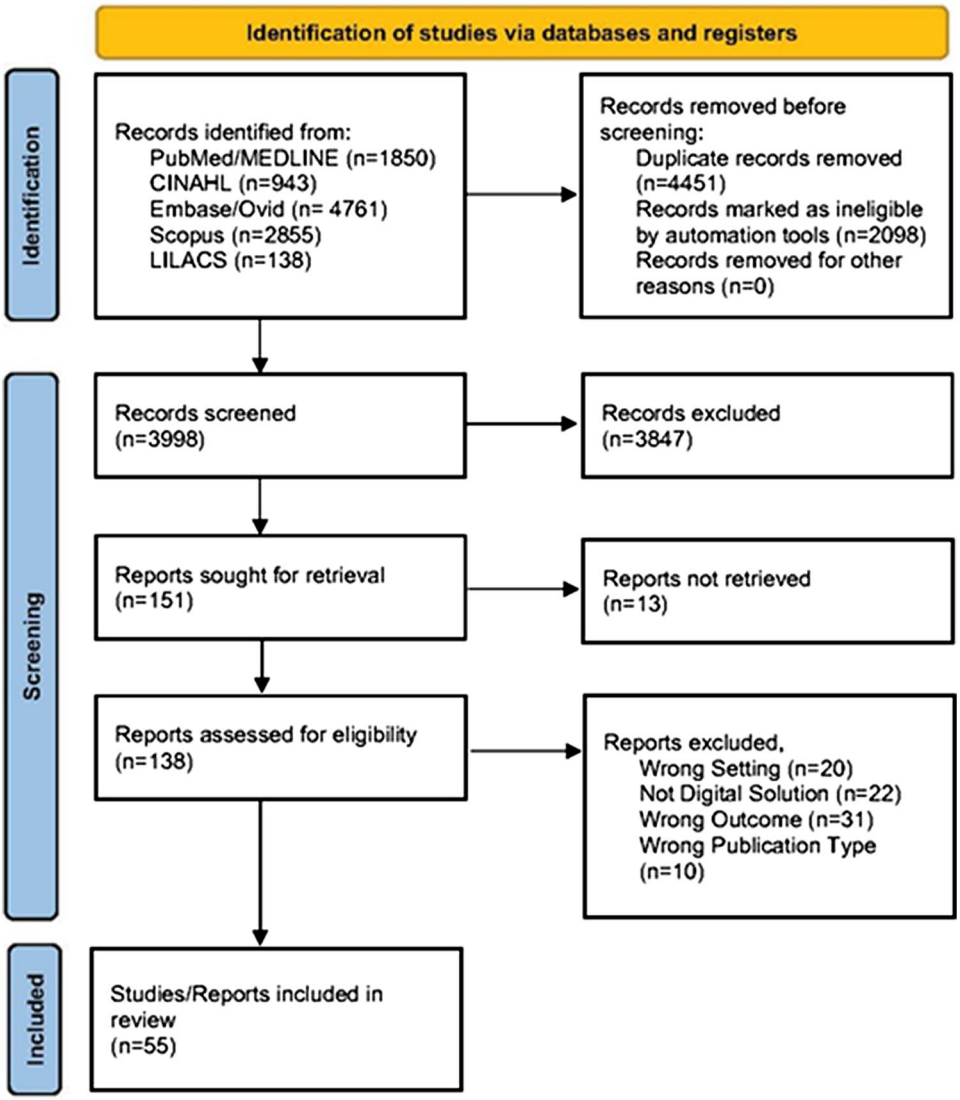


Figure 1 PRISMA flow diagram of study selection. Flow diagram adapted from PRISMA 2020.

Throughout the manuscript, coded entries refer to analytically distinct outcomes, mechanisms, implementation conditions or equity items extracted from individual studies. A single study could therefore contribute multiple coded entries.

Outcome and mechanism coding

Outcomes were organized according to their position along a hypothesized pathway from implementation conditions and proximal workforce determinants to intentions and, ultimately, observed retention or workforce stability [5]. Four prespecified tiers were used for evidence mapping: (A) direct observed retention or workforce stability; (B) intentions to stay or leave; (C) proximal determinants potentially influencing retention, including professional, organizational, and psychosocial conditions; and (D) implementation-related sustainability outcomes, including adoption, acceptability, feasibility, usability, and routine integration. Tiers C and D were not considered retention outcomes in themselves. Tier D outcomes were included only when explicitly linked to workforce conditions and were interpreted as implementation conditions potentially relevant to subsequent retention pathways. Mechanisms linking digital interventions to retention were coded as professional support, clinical support, organizational or workload, career development and skills, social or place-based retention, or adverse pathways. Mechanism source (author-, participant-, or reviewer-derived) and evidence basis (quantitative, qualitative, mixed or descriptive) were also recorded. The study-level coding matrix is provided in Table S2. The relationship between extraction domains and the interpretive synthesis is documented in Table S11, while the empirical basis underpinning each redistribution pathway is summarized in Table S12.

Critical appraisal

Consistent with scoping review methodology, formal critical appraisal was not undertaken because the objective was to map the breadth and characteristics of the evidence rather than estimate intervention effectiveness [12–14]. Study design, evidence basis and strength of claim were nevertheless charted to

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

support interpretation. These characteristics were used to calibrate the narrative synthesis and the strength of the conclusions. Findings from qualitative, cross-sectional, descriptive, and implementation-focused studies were interpreted as evidence of reported experiences, associations or potential pathways, rather than as evidence of causal effects on retention.

Synthesis

Findings were synthesized using descriptive statistics and structured narrative synthesis. Counts were generated for study characteristics, intervention types, outcome tiers, mechanisms, implementation conditions, and equity items. Evidence syntheses were retained to broaden conceptual mapping but were not used to strengthen claims about intervention effects because overlap with included primary studies could not be excluded. Because individual studies could contribute multiple coded entries, entry-level counts were treated as descriptive indicators of the range and direction of reported findings and not as independent estimates of intervention effects or of the proportion of studies demonstrating benefit.

Cross-domain comparison of outcomes, mechanisms, implementation conditions, and equity findings identified recurrent empirical patterns that informed an interpretive framework describing four redistribution pathways: labor, authority, dependency, and infrastructure risk. This framework represents an analytical interpretation of the mapped evidence rather than a taxonomy explicitly reported by the primary studies [17]. The relationship between extraction domains and the interpretive synthesis is documented in Table S11.

Results

Scope of the literature

The review included 55 sources. Mixed-methods and qualitative studies predominated (18 each), followed by quantitative cross-sectional ($n = 7$), cohort or longitudinal ($n = 5$), program descriptions ($n = 3$), two evidence syntheses, one non-randomized study, and one randomized trial. The evidence syntheses were retained to broaden conceptual mapping but interpreted cautiously because their underlying primary studies could overlap with included empirical studies.

The 55 sources represented 67 enumerated country settings across 26 countries. Australia and the United States were the most frequently represented, followed by India, Canada, and the United Kingdom. One evidence synthesis described 43 studies across 32 low- and middle-income and 11 high-income countries but did not enumerate individual countries. Most study instances originated from the Western Pacific and Americas regions (Table 1).

Most studies involved multiple professional groups. Physicians and nurses or midwives predominated, while community health workers, allied health professionals, pharmacists, mental health practitioners, emergency-care staff, and trainees were less frequently represented. Primary care was the most common setting, although hospital, community, district, and outreach services were also included (Table 1).

Digital interventions

Digital intervention data were available for all 55 sources. Telehealth or telemedicine was the most common primary intervention (27 sources), followed by tele-education or distance education (12 sources), multicomponent digital interventions (6 sources), clinical decision support (3 sources), AI-enabled functionalities (2 sources), workforce-management tools (2 sources), digital mentoring or supervision (2 sources), and one other intervention.

Digital interventions rarely functioned as stand-alone technologies. They were embedded within broader service-delivery, educational, supervisory, and organizational models. Clinical support was the predominant purpose, followed by mixed purposes and education or professional development. Synchronous and hybrid modalities predominated, with interventions delivered mainly through individual-, team-, facility-, or network-level models. Implementation ranged from pilot projects to routine services and scale-up, most commonly through hub-and-spoke arrangements led by health services or partnerships involving ministries, universities or non-governmental organizations (Table 1).

Retention outcomes

Outcome data were available for 54 sources, comprising 149 coded outcome entries. The evidence was predominantly indirect. Proximal determinants of retention accounted for 84 coded entries across 48 studies, and implementation-related sustainability outcomes for 47 entries across 27 studies. Direct observed retention or workforce-stability outcomes comprised only 10 entries across 9 studies, while intention-related outcomes accounted for 8 entries across 7 studies.

The most frequently reported outcomes concerned acceptability, professional isolation, autonomy, role confidence, continuing education, workload, integration into routine practice, burnout, job satisfaction, and supervision. Direct outcomes were limited to retention in post, recruitment, attrition, and duration of stay. Outcome direction was coded as positive for 98 entries, mixed for 32, negative for 15 and showing no clear change for 3; direction was not reported for 1 entry. Positive-coded entries occurred predominantly among proximal workforce determinants and implementation-related outcomes rather than direct measures of retention (Fig. 2). At study level, 45 studies reported at least one positive finding, 23 at least one mixed finding, 11 at least one negative finding, 2 at least one finding showing no clear change, and 1 an outcome for which direction was not reported. These categories are not mutually exclusive because individual studies could report outcomes in more than one direction.

Supportive pathways

Mechanism coding yielded 170 entries across all included sources. The most frequent mechanisms related to career development and skills, professional support, organizational or workload pathways, clinical support, and social or place-based retention. Continuing education, skill development, reduced professional isolation, improved coordination, specialist

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

Table 1 Characteristics of included sources, settings, digital intervention typology and implementation characteristics.[a]

Characteristic	Summary
Included sources	55 sources
Publication years	2015–25
Study designs	Mixed methods [18]; qualitative [18]; quantitative cross-sectional [7]; quantitative cohort/longitudinal [5]; program description [3]; scoping review [1]; systematic review [1]; quantitative non-RCT [1]; quantitative RCT [1]
Evidence syntheses counted as included sources	2 sources; retained for mapping breadth and interpreted separately where overlap-sensitive inferences could arise
Geographical coverage	67 enumerated country-settings across 26 countries; one additional evidence synthesis reported 43 sampled studies across multiple countries not individually enumerated
WHO region study-instances	Western Pacific region [19]; region of the Americas [18]; African region [12]; South-East Asia region [6]; European region [5]
Most frequent country-settings	Australia [15]; United States [15]; India [5]; Canada [4]; United Kingdom [3]
Broad occupational and implementation stakeholder groups	Managers/administrators/policy/IT [40]; doctors/physicians [38]; nurses/midwives [35]; community/lay health workers [16]; allied health/rehabilitation [10]; trainees/students/preceptors [8]; mental health/counselling [7]
Service level	Primary care [20]; mixed [21]; hospital [9]; community [4]; primary care + district health services + hospital care [1]; outreach [1]
Scale of intervention	Subnational [22]; national [12]; regional [9]; multiple levels [7]
Digital-solution records	55 of 55 sources had completed Domain 2 records
Primary solution type	Telehealth/telemedicine [22]; tele-education/distance education [12]; multicomponent digital package [6]; clinical decision-support [3]; AI-enabled functionality [2]; workforce management/administrative tools [2]; digital mentoring/supervision [2]; other [1]
Role of digital component	Core [43]; major [6]; minor [6]
Primary purpose	Clinical support [19]; mixed [17]; education/professional development [12]; management [2]; communication [2]; supervision [2]
Modality	Synchronous [23]; hybrid [21]; asynchronous [11]
Maturity stage	Routine use [19]; pilot [18]; early implementation/implementation [10]; scale-up [6]; mixed [1]
Implementation approach	Service-delivery model [16]; training-led [14]; multicomponent rollout [9]; workflow integration [9]; supervision/mentoring-led [3]; not reported [2]; workforce support/distance professional development [1]; service delivery plus training [1]
Delivery model	Hub-and-spoke [24]; other [6]; facility-based [6]; national platform [5]; mobile/outreach-linked [4]; distributed network [2]; peer network [1]; mixed [1]; not reported [1]
Implementing actor(s)	Mixed [21]; health service [17]; NGO [7]; university [6]; ministry [3]; hospital [2]; not reported [1]
Retention pathway targeted	Workflow/organizational support [13]; professional development [11]; supervision/support [10]; mixed/indirect retention pathway [10]; direct retention [5]; job experience [4]; unclear [2]
AI-enabled functionality	No [51]; yes [2]; unclear [2]

[a]Implementation stakeholders were coded separately from frontline occupational groups where reported; counts are not mutually exclusive.

support, decision confidence, and time saving were the most commonly reported mechanisms.

Collectively, these findings identify potential indirect pathways through which digital interventions may influence retention, including professional connection, learning opportunities, clinical support, and organizational functioning. However, the mapped evidence does not establish that changes in these proximal conditions subsequently resulted in improved workforce stability.

Redistribution pathways

Thirty adverse mechanism entries were identified across 24 studies. These included digital burden, increased workload, frustration or technostress, surveillance, reinforcement of inequalities, and dependence on fragile infrastructure.

Across the evidence, four recurring redistribution pathways emerged. Labor redistribution occurred when rural workers assumed additional coordination, documentation or technical

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

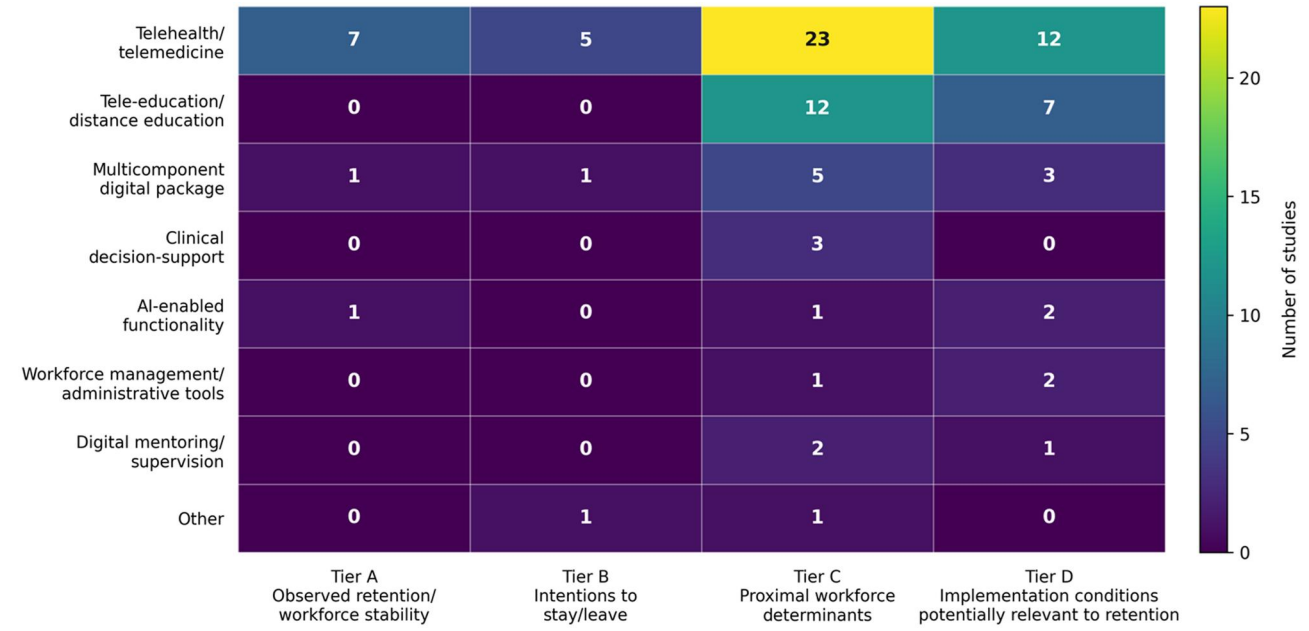


Figure 2 Number of studies reporting outcomes in each evidence tier, by primary digital intervention. Studies could contribute to more than one tier. Tier A comprises observed retention or workforce-stability outcomes; Tier B, intentions to stay or leave; Tier C, proximal workforce determinants; and Tier D, implementation conditions potentially relevant to retention. Tiers C and D are not retention outcomes in themselves.

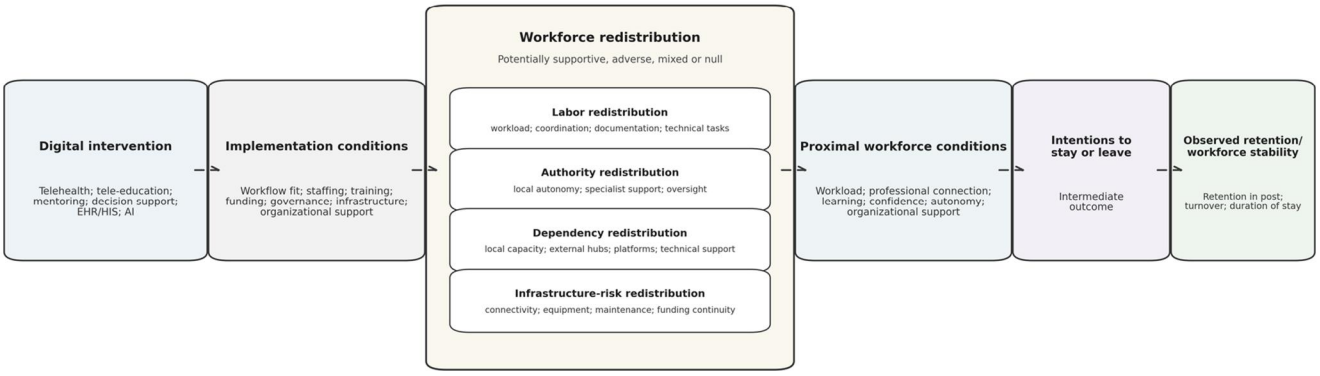


Figure 3 Hypothesized pathway linking digital interventions to rural workforce retention. Implementation conditions shape how digital interventions redistribute labor, authority, dependency and infrastructure risk, with potentially supportive, adverse, mixed or null consequences for proximal workforce conditions, intentions to stay or leave and, ultimately, observed retention or workforce stability. Dashed arrows represent hypothesized relationships for evaluation, not established direct causal effects. These pathways may unfold over different timescales and are influenced by context, and complementary non-digital workforce supports.

tasks. Authority redistribution reflected changing relationships between local autonomy and external expertise through remote supervision, specialist consultation or digital monitoring. Dependency redistribution described increasing reliance on specialist networks, digital platforms or external technical support. Infrastructure-risk redistribution occurred when limitations in connectivity, equipment, maintenance, electricity, funding, or technical support transferred implementation risks to rural facilities and frontline workers. Each redistribution pathway may have supportive or adverse workforce consequences depending on its direction, implementation context, and interaction with organizational conditions; the pathways should not be interpreted as demonstrated causal effects on retention (Fig. 3).

Implementation and equity

Implementation coding generated 196 entries. Organizational readiness was the most frequent category, followed by user and sociocultural factors, infrastructure, financing, and governance. Facilitators (82 entries) slightly outnumbered barriers (68 entries), while 46 were mixed. Workflow fit, acceptability, connectivity, staffing, training, equipment, policy support, and recurrent funding were the most frequently reported implementation conditions. Financing and infrastructure were predominantly reported as barriers.

Equity and evidence-gap coding yielded 126 entries. Frequently identified issues included unintended positive

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

consequences, burden shifting, geographical inequities, digital exclusion, limited long-term follow-up and the absence of direct retention outcomes. Rurality was inconsistently defined; implementation detail was often limited and professional groups beyond physicians and nurses remained comparatively underrepresented.

Discussion

Main message

This review shows that the literature on digital health and rural workforce retention is primarily a literature of retention pathways rather than retention effects. Most studies evaluated proximal workforce or implementation outcomes, whereas direct measures of retention, turnover or workforce stability were uncommon. Rather than demonstrating whether digital interventions improve retention, the evidence describes how they reshape the professional, organizational, and technical conditions that influence whether rural health and care workers can remain, develop, and practice sustainably. These domains occupy different positions and timescales within a hypothesized pathway: implementation outcomes may emerge during early adoption, proximal workforce conditions and intentions may change over a longer period, and observable effects on turnover or duration of stay may require several years.

This interpretation is consistent with broader rural workforce evidence, which conceptualizes retention as the product of interacting professional, organizational, social, and place-based conditions rather than isolated interventions [5, 7, 8, 18, 21]. Across the mapped evidence, digital interventions most frequently influenced professional connection, supervision, continuing education, clinical confidence, workflow integration, and organizational support. At the same time, they could increase administrative workload, reinforce dependence on external expertise or transfer implementation burdens to already resource-constrained rural services.

The principal contribution of this review is therefore not to establish the effectiveness of digital interventions for retention, but to identify the workforce pathways through which digitalization may strengthen or weaken rural workforce sustainability. The redistribution framework developed from the mapped evidence provides a structured way of examining these pathways by distinguishing changes in labor, authority, dependency, and infrastructure risk. It represents an interpretive synthesis of recurring empirical patterns rather than evidence of causal relationships or a taxonomy explicitly reported by the primary studies [11, 17].

Digital health as workforce redistribution

Viewed collectively, the evidence suggests that digital health is best understood not only as a service-delivery intervention but also as a process of workforce redistribution. Across diverse settings and intervention types, digital interventions repeatedly altered who performed coordination and documentation work, how professional authority was shared between rural providers and specialist services, which dependencies were created through digital networks and where implementation risks were ultimately absorbed.

The same intervention could therefore strengthen or undermine workforce sustainability depending on how it was implemented. None of the four redistribution pathways is inherently beneficial or adverse. Labor redistribution may reduce or increase workload; authority redistribution may strengthen clinical confidence or weaken local autonomy; dependency on specialist networks may reduce professional isolation while creating reliance on external providers; and digital infrastructure may expand access while exposing rural services to new forms of operational vulnerability. The Lynx mHealth program in rural Zambia improved communication and reporting while simultaneously increasing documentation demands for frontline staff, illustrating labor redistribution [19] In contrast, the ImTeCHO program in rural India combined digital tools with training, mentoring, and organizational support, demonstrating that additional responsibilities need not become burdensome when implementation is adequately resourced [20]. Teleconsultation models reshaped professional authority by combining local decision-making with specialist support [25], while emergency telehealth models illustrated how increased access to expertise could also increase dependence on external hubs if local capacity was not strengthened [26]. Infrastructure constraints, including unreliable connectivity, limited equipment, and insufficient technical support, further showed how implementation risks were frequently transferred to rural facilities rather than managed at system level [27].

These examples illustrate a broader pattern rather than isolated findings. Whether digital interventions contribute to rural workforce sustainability depends less on technology itself than on how labor, authority, dependency, and infrastructure risk are distributed across the health system.

What this study adds

This review extends the literature in three ways. First, it demonstrates that the evidence base is dominated by proximal workforce and implementation outcomes rather than direct measures of retention. Second, it integrates heterogeneous findings through a redistribution perspective that links digital interventions to changes in labor, authority, dependency, and infrastructure risk. Third, it provides a structured framework for evaluating whether digital interventions strengthen rural workforce sustainability or transfer additional burden and fragility to rural workers and facilities.

Scoping reviews are designed primarily to map the extent, characteristics and gaps of an evidence base, but they may also contribute to conceptual clarification by integrating recurrent patterns across heterogeneous sources [12, 13] The framework proposed here should therefore be understood as an interpretive contribution grounded in the mapped evidence rather than as evidence that digital health improves retention.

Implications for evaluation and policy

Future evaluations should move beyond implementation success or service activity alone and specify an explicit retention pathway before implementation: which workforce condition is

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

expected to change, for whom, through which mechanism, over what timeframe, and with what possible redistribution of labor, authority, dependency, or infrastructure risk.

Minimum reporting should include the definition of rurality, cadre-specific effects, intervention intensity, workflow changes, training and support, infrastructure readiness, governance arrangements, and responsibility for additional work. Evaluations should also distinguish the contribution of digital interventions from complementary organizational or non-digital supports and examine whether digitalization strengthens local professional autonomy, increases dependence on external providers or transfers implementation risk to rural teams.

For policy, digital health should be designed around workforce sustainability rather than patient reach alone. The mapped evidence suggests that reducing professional isolation, strengthening clinical support, ensuring workflow fit, protecting professional autonomy, and providing reliable infrastructure, adequate resources and sustained organizational support are plausible conditions through which digital interventions may contribute to retention. However, these conditions should be tested prospectively against direct measures of workforce stability.

Recommendations for future research

Future studies should combine direct measures of workforce stability with prospective assessment of the mechanisms through which digital interventions may influence retention. Vacancy, turnover, and duration of stay remain important [23], but they should be interpreted alongside workload, professional isolation, supervision, autonomy, digital competence, infrastructure reliability, and perceived organizational support [28, 22].

Because retention is shaped by multiple interacting factors, digital interventions should also be evaluated alongside broader workforce strategies, including financial incentives, supervision, continuing professional development, and locally adapted organizational support.

The limited representation of AI-enabled interventions precludes conclusions regarding their effects on retention. Future research should examine whether AI redistributes decision authority, accountability, and surveillance in ways that influence rural workforce experience [29], while also assessing digital workload, technical burden, and digital competence as potential determinants of workforce sustainability [24, 30].

Strengths and limitations

This review followed a prospectively registered protocol, applied established JBI and PRISMA-ScR guidance and used structured coding across interventions, outcomes, mechanisms, implementation conditions, and equity considerations. The synthesis combined systematic evidence mapping with an interpretive framework explicitly grounded in recurrent empirical patterns.

Several limitations should be considered. No formal critical appraisal was undertaken, and the evidence was dominated by qualitative, mixed-methods, cross-sectional, and implementation-focused studies. The synthesis therefore identifies potential pathways rather than causal effects on retention. Direct retention measures were uncommon, and heterogeneity precluded quantitative synthesis. Restriction to English, Spanish, and Portuguese may have introduced language and geographical bias, while excluding grey literature may have omitted relevant programme evaluations. The 2015–25 timeframe prioritized contemporary digital systems but excluded earlier telemedicine evidence. The two evidence syntheses were interpreted cautiously because of possible overlap with included studies. Finally, the redistribution framework is interpretive rather than validated, and outcome-tier counts exclude Luscombe *et al.* [31], for which no distinct outcome was coded.

Conclusions

This review shows that the current evidence on digital health and rural workforce retention is primarily evidence about retention pathways rather than retention effects. Most studies evaluated proximal workforce or implementation outcomes, while direct measures of retention and workforce stability remained uncommon.

Viewing digital health through a sociotechnical workforce lens helps explain these findings. Rather than functioning solely as service-delivery technologies, digital interventions may redistribute labor, authority, dependency, and infrastructure risk across rural health systems. Whether these redistributions strengthen or undermine workforce sustainability depends on how interventions are implemented, resourced, and integrated into local practice. Digital health should therefore be evaluated as a sociotechnical workforce intervention. Future research and policy should move beyond implementation success alone and examine how digital interventions reshape the conditions that enable health and care workers to remain, develop, and practice sustainably in rural and underserved settings.

Supplementary data

Supplementary data are available at *EURPUB* online.

Conflicts of interest

Tiago Correia is Editor-in-Chief of the European Journal of Public Health and had no involvement in the editorial handling or decision concerning this manuscript. Tomas Zapata, Sulakshana Nandi, David Novillo-Ortiz, Shirin Kiani, Cathal Morgan, and Margrieta Langins are staff members of the WHO Regional Office for Europe. The Instituto de Higiene e Medicina Tropical, Universidade NOVA de Lisboa, received funding from the WHO Regional Office for Europe to undertake this work. The views expressed are those of the authors and do not necessarily represent the decisions or policies of WHO or the European Commission. The remaining authors declare no competing interests.

Funding

This work was commissioned by the WHO Regional Office for Europe under an Agreement for Performance of Work (APW) for

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

the development of a technical brief on digital technologies and health workforce retention in rural and remote areas. The APW was implemented within a program funded by the European Commission (DG NEAR). The publication is supported by national funds through FCT—Fundação para a Ciência e a Tecnologia, I.P., under the R&D unit Global Health and Tropical Medicine (UID/04413/2025), and the Associated Laboratory in Translation and Innovation Towards Global Health REAL (LA/P/0117/2020). The funders had no role in the interpretation of the findings or the decision to submit this manuscript for publication.

Data availability

The study extraction matrix, coding framework, traceability tables, and analytical datasets supporting the findings of this study are provided as Supplementary Material.

Key points

- Digital health in rural, remote or underserved settings is more often evaluated through implementation and proximal workforce outcomes than through direct observed retention outcomes.
- Digital health should be evaluated through workforce redistribution pathways as well as direct retention outcomes.
- Supportive pathways include supervision, specialist backup, reduced isolation, continuing education, role confidence, and workflow support.
- Adverse redistribution pathways involve labor, authority, dependency, and infrastructure risk, including workload transfer, hub dependence, surveillance/control, digital exclusion and fragile infrastructure.
- Future evaluations should measure direct workforce stability while also assessing whose work, autonomy, dependency and risk are changed by digitalization.

References

1. Kuhlmann E, Lotta G, Dussault G *et al.* The workforce crisis in healthcare: moving the debate to bridge evidence and policy. *Int J Health Plann Manage* 2024;**39**:607–13. https://doi.org/10.1002/hpm.3792
2. Azzopardi-Muscat N, Zapata T, Kluge H. Moving from health workforce crisis to health workforce success: the time to act is now. *Lancet Reg Health* 2023;**35**:100765. https://doi.org/10.1016/j.lanepe.2023.100765
3. Ungureanu MI, Falkenbach M, Kuhlmann E *et al.* Responding to current and future challenges in the health and care workforce: linking innovative research, policies, and practices. *Eur J Public Health* 2026;**36**:i1–i2. https://doi.org/10.1093/eurpub/ckaf243
4. Lopes Q, Martins T, Correia T. Risk perception among healthcare professionals working in emergency care in remote locations: a scoping review. Rural Remote Health 2026;**26**:1–11. https://doi.org/10.22605/RRH9911
5. WHO. WHO guideline on health workforce development, attraction, recruitment and retention in rural and remote areas. Geneva, 2021. Date accessed 14 July 2026. https://www.who.int/publications/i/item/9789240024229
6. WHO. *National Health Workforce Accounts: A Handbook*. Geneva: WHO, 2023. Date accessed 14 July 2026. https://www.who.int/publications/i/item/9789240081291
7. Carson DB, Johansson AB, Schaumberg M *et al.* Addressing the workforce crisis in (rural) social care: a scoping review. *Int J Health Plann Manage* 2024;**39**:806–23. https://doi.org/10.1002/hpm.3774
8. Cosgrave C, Malatzky C, Gillespie J. Social determinants of rural health workforce retention: a scoping review. *Int J Environ Res Public Health* 2019;**16**:314. https://doi.org/10.3390/ijerph16030314
9. MacAskill W, Gill P, Woloszczuk C *et al.* A systematic review of the scope and impact of rural primary healthcare innovations using digital health technology. *BMJ Open.* 2026;**16**:e097874. https://doi.org/10.1136/bmjopen-2024-097874
10. Borges do Nascimento IJ, Abdulazeem HM, Vasanthan LT *et al.* The global effect of digital health technologies on health workers' competencies and health workplace: an umbrella review of systematic reviews and lexical-based and sentence-based meta-analysis. *Lancet Digit Health* 2023;**5**:e534–44. https://doi.org/10.1016/S2589-7500(23)00092-4
11. Greenhalgh T, Abimbola S. *The NASSS Framework – A Synthesis of Multiple Theories of Technology Implementation. Em: Applied Interdisciplinary Theory in Health Informatics*. IOS Press, 2019, 193–204. Date accessed 15 July 2026. https://ebooks.iospress.nl/doi/10.3233/SHTI190123 https://doi.org/10.3233/SHTI190123
12. Tricco AC, Lillie E, Zarin W *et al.* PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;**169**:467–73. https://doi.org/10.7326/M18-0850
13. Munn Z, Peters MDJ, Stern C *et al.* Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol* 2018;**18**:143. https://doi.org/10.1186/s12874-018-0611-x
14. Aromataris, E Lockwood, C Porritt, K *et al. JBI Manual for Evidence Synthesis*. Adelaide: JBI, 2024.
15. Page, Matthew J, McKenzie, Joanne E, Bossuyt, Patrick M, *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;**372**:n71. https://doi.org/10.1136/bmj.n71
16. Correia T, da Conceiçao Pereira A, Zapata T *et al.* Role of digital solutions in improving retention of health and care workers in rural and remote areas: a scoping review. https://osf.io/an6mj/overview (14 July 2026, date last accessed).
17. Dixon-Woods M, Agarwal S, Jones D *et al.* Synthesising qualitative and quantitative evidence: a review of possible methods. *J Health Serv Res Policy* 2005;**10**:45–53. https://doi.org/10.1177/135581960501000110
18. Jankelová N, Dabić M, Maley JF *et al.* Junior doctor retention strategies: integrating knowledge management with supportive leadership and organizational climate. *J Knowl*

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

Econ 2024;**16**:13166–92. https://doi.org/10.1007/s13132-024-02316-x
19. Montaner A, Mumbalanga M, Umuhoza M-C *et al.* Health worker acceptability of an HIV testing mobile health application within a rural Zambian HIV treatment programme. *PLoS One* 2025;**20**: e0312646. https://doi.org/10.1371/journal.pone.0312646
20. Modi D, Gopalan R, Shah S *et al.* Development and formative evaluation of an innovative mHealth intervention for improving coverage of community-based maternal, newborn and child health services in rural areas of India. *Glob Health Action* 2015;**8**:26769. https://doi.org/10.3402/gha.v8.26769
21. De Vries N, Lavreysen O, Boone A *et al.* Retaining healthcare workers: a systematic review of strategies for sustaining power in the workplace. *Healthcare (Basel)* 2023;**11**:1887. https://doi.org/10.3390/healthcare11131887
22. McPake B, Dayal P, Zimmermann J *et al.* How can countries respond to the health and care workforce crisis? Insights from international evidence. *Int J Health Plann Manage* 2024;**39**:879–87. https://doi.org/10.1002/hpm.3766
23. Maniscalco L, Enea M, de Vries N *et al.* Intention to leave, depersonalisation and job satisfaction in physicians and nurses: a cross-sectional study in Europe. *Sci Rep* 2024;**14**: 2312. https://doi.org/10.1038/s41598-024-52887-7
24. Williams GA, Falkenbach M, van Schaaijk A *et al. Closing the Digital Skills Gap in Health Care: Identifying Core Digital Skills and Competencies and Education and Training Opportunities for Health Professionals in the European Union. Policy Brief 71*. Copenhagen: European Observatory on Health Systems and Policies, WHO Regional Office for Europe, 2025. Date accessed 14 July 2026. https://eurohealthobservatory.who.int/publications/i/closing-the-digital-skills-gap-in-health-care-identifying-core-digital-skills-and-competencies-and-education-and-training-opportunities-for-health-professionals-in-the-european-union
25. Paul DL, McDaniel RR. Facilitating telemedicine project sustainability in medically underserved areas: a healthcare provider participant perspective. *BMC Health Serv Res* 2016;**16**: 148. https://doi.org/10.1186/s12913-016-1401-y
26. Osman S, Churruca K, Jalali MS *et al.* Conceptualising the impact of telehealth on rural workforce sustainability using system dynamics and the Gartner hype cycle. *Npj Health Syst* 2025;**2**:38. https://doi.org/10.1038/s44401-025-00044-1
27. Nazari JL, Kulbokas V, Smart MH *et al.* Implementation of virtual academic detailing in North America: a qualitative study. *J Eval Clin Pract* 2024;**30**:693–702. https://doi.org/10.1111/jep.13997
28. Zapata T, Azzopardi-Muscat N, McKee M *et al.* Fixing the health workforce crisis in Europe: retention must be the priority. *BMJ* 2023;**381**:947. https://doi.org/10.1136/bmj.p947
29. Sujithra R, Bini Marin V, Sreya B. Commentary: leveraging big data in health care and public health for AI driven talent development in rural areas. *Front Public Health* 2025;**13**: 1685569. https://doi.org/10.3389/fpubh.2025.1685569
30. Eric Topol. *The Topol Review: Preparing the Healthcare Workforce to Deliver the Digital Future*. London: NHS England, 2019. https://topol.digitalacademy.nhs.uk/the-topol-review
31. Luscombe GM, Hawthorn J, Wu A *et al.* 'Empowering clinicians in smaller sites': a qualitative study of clinician's experiences with a rural virtual paediatric feeding clinic. *Aust J Rural Health* 2021;**29**:742–52. https://doi.org/10.1111/ajr.12781

Downloaded from academic.oup.com/eurpub/article/36/5/ckag177/8846963 by guest on 16 October 2026

© The Author(s) 2026. Published by Oxford University Press on behalf of the European Public Health Association.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (https://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact reprints@oup.com for reprints and translation rights for reprints. All other permissions can be obtained through our RightsLink service via the Permissions link on the article page on our site—for further information please contact journals.permissions@oup.com.
European Journal of Public Health, 2026, 36, 1–10
https://doi.org/10.1093/eurpub/ckag177
Original Manuscript