

DELIVERING PRIMARY HEALTHCARE IN REMOTE AND ISOLATED SETTINGS: A GLOBAL REVIEW OF MARITIME, OFFSHORE, AND RURAL SERVICE MODELS

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ABSTRACT

Background: Primary healthcare in geographically remote and operationally isolated settings is organised very differently across rural, maritime and offshore domains, and the literatures describing these domains have developed largely in isolation from one another. Comparative accounts that read them together are scarce. Methods: We conducted a structured narrative review, reported against the Scale for the Assessment of Narrative Review Articles (SANRA) and using PRISMA 2020 conventions to report search and selection. Eight bibliographic databases (MEDLINE, Embase, Scopus, Web of Science, CINAHL, LILACS, African Journals OnLine and the Cochrane Library) were searched from January 2000 to [month] 2025, supplemented by hand-searching of International Maritime Health, citation chaining, and targeted retrieval of regulatory and technical instruments from the International Labour Organization, the International Maritime Organization, the World Health Organization and national offshore safety regulators. Sources addressing the organisation, delivery, workforce, technology, governance or financing of first-contact healthcare in settings meeting a stated operational definition of remoteness were eligible. Included sources were assigned an explicit three-level rating of evidentiary strength. Synthesis was thematic, followed by framework comparison against a common extraction matrix. Results: Included sources describe nine distinct service configurations across the three domains. Six mechanisms recur across all of them: a competent first-line responder positioned inside the isolated unit whose scope is set by protocol rather than profession; a system-level guarantee of access to distant clinical expertise; a pre-defined and resourced escalation pathway with a named destination; continuity of the clinical record across the escalation boundary; electrical power and communications treated as clinical rather than ancillary infrastructure; and supervision with periodic recertification as the mechanism sustaining delegated scope. Six features do not transfer: the logic of the population denominator, the demand profile, the source of regulatory leverage, the stability of time-to-definitive-care, the applicability of community participation, and the identity of the cost-bearer. Maritime and offshore capability is set by binding instruments attached to the flag State or the employer and can be raised by amending an instrument; rural capability is set by public budgets and has no equivalent lever. Conclusions: The evidence assembled suggests that no single service model is universally transferable, and indicates that transferability operates at the level of mechanism rather than of model. Remote primary healthcare is better designed as an integrated and adaptive system than as a collection of discrete interventions. Priorities include place-sensitive workforce strategies, dependable financing, strengthened referral networks, interoperable telehealth, resilient energy and communication systems, and cross-sector coordination. The maritime domain, and commercial fishing in particular, remains substantially under-researched relative to its occupational risk.

Keywords: Rural Health Services; Health Services Accessibility; Telemedicine; Naval Medicine; Primary Health Care; Community Health Workers; Occupational Health

1. INTRODUCTION

1.1 Geography, inequality and the organisation of first-contact care

Primary healthcare in remote and isolated settings sits at the intersection of geography, social inequality, workforce distribution and infrastructure. Across continents, populations living far from metropolitan centres encounter longer journeys, limited transport, weak referral networks and reduced availability of skilled professionals. Isolation arises in archipelagic territories, offshore installations, mountainous settlements, deserts, riverine basins and sparsely populated coastal regions, and it also arises aboard vessels, where the population is mobile and the distance to definitive care changes continuously.

The problem is not simply that facilities are far away. In Nigeria, geospatial analysis of primary healthcare facilities has demonstrated that aggregate accessibility statistics conceal local pockets in which settlements remain substantially distant from care, which is why remoteness must be understood at community rather than national level (Lawal & Anyiam, 2019). Geographic modelling in Ghana's Ashanti Region similarly found marked differences between access to primary, secondary and tertiary services, with rural districts particularly exposed to longer journeys (Ashiagbor *et al.*, 2020). The physical presence of a facility does not by itself produce effective access: travel time, transport availability, terrain and service capacity together determine whether populations obtain timely treatment.

Where settlements are dispersed, conventional fixed-facility models may be insufficient. In the rural Eastern Cape of South Africa, mobile outreach services supported by a non-governmental organisation extended primary healthcare to communities beyond practical walking distance from fixed clinics and recorded substantial utilisation, indicating that service configuration should respond to settlement patterns rather than expecting marginalised populations to absorb the costs of distance (Morris-Paxton, Reid & Ewing, 2020). Archipelagic states face a related problem at a different scale. Indonesia combines dispersed islands, uneven infrastructure and substantial differences in health-personnel distribution; national evidence indicates that primary-care availability and utilisation vary across remote and non-remote provinces, and that geographical isolation interacts with poverty, insurance arrangements and referral behaviour (Wenang *et al.*, 2021). An integrative review of rural primary healthcare in Latin America reached a comparable conclusion, emphasising that "rural" and "remote" are heterogeneous conditions and that models suitable for agricultural hinterlands may not transfer to riverine, forest, island or frontier communities (Franco, Lima & Giovanella, 2021).

Workforce availability is a structural determinant of performance in all of these settings. A systematic review of rural and remote workforce retention found stronger retention associations with rural-origin recruitment, substantial rural training exposure and opportunities for professional development than with coercive return-of-service mechanisms (Russell *et al.*, 2021), and a multi-country framework analysis reached similar conclusions about the organisational conditions under which remote rural services achieve workforce stability (Abelsen *et al.*, 2020). Staffing cannot be treated simply as deployment.

Maritime and offshore environments extend these problems beyond conventional rural geography. Offshore installations may be separated from land-based medical services by long distances, difficult weather and limited specialist availability, and telemedical systems have become central to connecting personnel at sea with shore-based expertise. Quality assurance in that link is not automatic: a scoping review of offshore telemedical care identified the need for measurable standards addressing provider qualifications, technical infrastructure, communication, documentation, privacy and clinical process, rather than assuming that connectivity alone guarantees quality (Hellfritz, Waschkau & Steinhäuser, 2021). Operational experience from offshore wind environments illustrates how digital connectivity, trained first responders and organised evacuation pathways can mitigate the consequences of isolation, while weather, communications reliability and transport constraints remain decisive (Mastella *et al.*, 2022).

1.2 Distance, access and the limits of proximity

Geographic isolation operates through more than kilometres. Travel time, transport availability, terrain, weather, road quality and the distribution of health workers collectively determine whether a nominally available service is practically reachable, and the choice of accessibility metric materially changes which populations are identified as underserved. National geospatial analysis in Kenya showed county-level variation in travel time to public and private facilities, with the most geographically marginalised populations concentrated in sparsely served areas (Moturi *et al.*, 2022); evidence from rural Madagascar found that consultation rates with community health workers declined as household distance increased, indicating that community-level provision reduces but does not eliminate geographic barriers (Evans *et al.*, 2022); and in rural Haiti, alternative measures of distance and travel time produced materially different estimates of accessibility, underscoring the methodological importance of modelling transport networks and terrain (Bhangdia *et al.*, 2022). Taken together, these three studies establish that the measurement of distance is itself a determinant of what planners can see.

Proximity is also insufficient on its own. Collaboration with trusted community connectors in rural Ireland and Australia demonstrated that geographic accessibility intersects with social marginalisation, local knowledge and institutional relationships, so that reaching isolated populations requires both spatial proximity and service models capable of crossing social boundaries (Wallace *et al.*, 2020). Infrastructure reliability conditions whether a geographically accessible facility can provide continuous care at all; that argument is developed with the relevant health-facility evidence in Section 6.3.

1.3 Rationale for comparing remote service models

Comparing remote healthcare service models is necessary because geographical isolation produces materially different service constraints. Vessels, offshore platforms, islands and rural settlements differ in population density, transport reliability, workforce availability, evacuation capacity and infrastructure, so a model that is effective in one isolated environment may be inefficient or infeasible in another. Australian evidence identifies discrete, integrated, comprehensive, outreach and virtual-outreach approaches whose suitability changes with remoteness and population scale (Wakerman *et al.*, 2008), which is precisely why comparative analysis should examine contextual fit rather than assume a universally optimal configuration.

Nigeria illustrates why strengthening rural primary healthcare requires more than increasing facility numbers. A quality-improvement intervention in rural Nigerian facilities showed that governance support, performance monitoring and locally responsive implementation influence service quality, while operational constraints limit sustainability (Okoli *et al.*, 2016). Community organisation differentiates models further: Ghana's Community-based Health Planning and Services programme shows that bringing primary care closer to underserved populations depends on community engagement, frontline responsiveness and faithful adaptation during scale-up (Kushitor *et al.*, 2019). Evidence from remote rural Brazil shows that socioeconomic conditions, transportation, service organisation, community-health-worker functions and digital support shape primary-care configurations (Almeida *et al.*, 2021), and Canadian work on community-oriented approaches emphasises durable relationships, multidisciplinary practice, Indigenous perspectives and governance in resource-dependent settings (Buse *et al.*, 2022). Reading these alongside maritime and offshore systems can clarify which mechanisms compensate for distance and which are artefacts of a particular health system.

1.4 Aim, scope and objectives

This review examines how primary healthcare is organised, delivered, sustained and adapted across geographically remote and operationally isolated environments, with particular attention to maritime, offshore and rural settings. Its purpose is to identify the structural, technological, workforce, organisational and contextual factors that influence accessibility, continuity, quality and responsiveness

where conventional facility-based models are constrained by distance, limited infrastructure, environmental exposure or workforce scarcity.

The scope encompasses rural primary healthcare facilities, community-based outreach systems, mobile and fluvial clinics, community health worker programmes, hub-and-spoke configurations, onboard care aboard merchant vessels, passenger vessels and medical ships, healthcare provision to fishing fleets, and medical arrangements on fixed offshore installations. The review also considers governance, financing, workforce development, task sharing, digital technologies, energy and communications infrastructure, and intersectoral coordination.

The objectives are to (i) identify the primary healthcare service models used in remote and isolated settings; (ii) compare their operational characteristics across rural, maritime and offshore contexts against a common extraction framework; (iii) identify recurrent barriers to equitable access and service continuity; (iv) examine enabling technologies, workforce strategies, governance arrangements and infrastructure requirements; and (v) determine which mechanisms transfer across settings and which are context-dependent. Objective (ii) is addressed in Tables 3 and 4, and objective (v) in Section 7.

2. METHODS

2.1 Design and reporting

This is a structured narrative review. It is not a systematic review, and no claim of exhaustive retrieval is made. The review is reported against the Scale for the Assessment of Narrative Review Articles (SANRA), which specifies requirements for the justification of importance, statement of aims, description of the literature search, referencing of statements, appropriate presentation of evidence and scientific reasoning (Baethge, Goldbeck-Wood & Mertens, 2019). Search and selection are reported using the conventions of the PRISMA 2020 statement (Page *et al.*, 2021), including a flow account of records identified, screened, assessed and included, in order to make the sampling of the literature auditable.

2.2 Operational definitions

The constructs that bound this review were defined operationally before searching, because they are the paper's central analytic categories and because a purely discursive definition would not support reproducible inclusion decisions.

- Remote or isolated setting. A population or workforce that (i) lies outside the routine catchment of a facility offering comprehensive primary healthcare, and (ii) cannot reach definitive care without crossing a discontinuity in the transport network — a sea passage, an air transfer, a waterway crossing, or a surface journey normally exceeding two hours. Both conditions must be satisfied. This deliberately excludes urban and peri-urban populations whose access barriers are primarily socioeconomic, organisational or intra-urban transport barriers, which are a distinct problem with a distinct literature.
- Rural. A land-based population meeting the definition above, resident in a defined geographic catchment, whose members are permanently domiciled there.
- Maritime. A population aboard a vessel underway or at anchor, including merchant ships, passenger and cruise vessels, medical ships, naval vessels and fishing vessels. Distance to definitive care is treated as a continuously varying quantity.
- Offshore. A workforce on a fixed or floating installation not under way — oil and gas platforms, drilling rigs, accommodation units and offshore wind installations — for which evacuation is normally by helicopter or dedicated vessel within a defined window.
- Definitive care. The level of care at which the presenting condition can be resolved rather than stabilised; for most of the models reviewed, a secondary or tertiary hospital ashore.

- First-contact or primary healthcare capability. The capacity to assess, treat or appropriately refer an undifferentiated presentation at the point of first contact, irrespective of the professional qualification of the person providing it.

2.3 Information sources

Eight bibliographic databases were searched: MEDLINE (Ovid), Embase (Ovid), Scopus, Web of Science Core Collection, CINAHL (EBSCO), LILACS, African Journals OnLine and the Cochrane Library. Searches were run on [insert date] and cover the period 1 January 2000 to [insert month] 2025.

Because the maritime and offshore domains are governed substantially by instruments that are not indexed in bibliographic databases, four further sources were searched purposively: the International Labour Organization NORMLEX database of conventions and their codes; International Maritime Organization publications and circulars; World Health Organization publications and IRIS; and the published requirements of national offshore safety regulators (the Health and Safety Executive in the United Kingdom, the Norwegian Ocean Industry Authority, and the Netherlands oil and gas industry standards). The journal International Maritime Health was hand-searched across the full period. Backward and forward citation chaining was performed on all included reviews and on any source contributing a row to the comparison matrix.

2.4 Search strategy

The full MEDLINE (Ovid) strategy is reproduced in Table 1. Strategies for the remaining seven databases, translated for each platform's-controlled vocabulary and syntax, are provided in Supplementary File 1. The strategy combines a geography-of-isolation concept, a maritime and offshore concept, and a primary-care and access concept, with the first two combined by OR and the result combined with the third by AND.

Table 1: Full search strategy, MEDLINE (Ovid). Strategies for the remaining seven databases are provided in Supplementary File 1.

#	Search terms
1	exp Rural Health Services/
2	exp Rural Population/
3	exp Medically Underserved Area/
4	(rural or remote or isolated or "hard to reach" or underserved or "hard-to-reach").ti,ab.
5	(island* or archipelag* or riverine or fluvial or hinterland*).ti,ab.
6	or/1-5
7	exp Naval Medicine/
8	(seafarer* or ship* or vessel* or maritime or "at sea" or shipboard or "merchant navy" or "merchant marine" or crew*).ti,ab.
9	(offshore adj3 (platform* or installation* or rig* or wind or petroleum or "oil and gas")).ti,ab.
10	(fisher* or "fishing vessel*" or trawler* or "catching sector").ti,ab.
11	(cruise adj2 (ship* or vessel* or line*)).ti,ab.
12	("medical ship*" or "hospital ship*").ti,ab.
13	or/7-12
14	exp Primary Health Care/
15	exp Community Health Services/
16	exp Health Services Accessibility/
17	exp Telemedicine/
18	exp Community Health Workers/
19	exp Mobile Health Units/

20	("primary care" or "primary health*" or "first contact" or "first-contact" or "community health worker*" or "task shift*" or "task shar*" or telehealth or telemedicine or "mobile clinic*" or outreach or evacuat* or medevac or "medical evacuation").ti,ab.
21	or/14-20
22	(6 or 13) and 21
23	limit 22 to yr="2000 - 2025"
24	limit 23 to (english or french or portuguese or spanish)

2.5 Eligibility criteria

Inclusion and exclusion criteria are set out in full in Table 2. In summary, eligible sources were peer-reviewed empirical studies, systematic and scoping reviews, and authoritative regulatory, normative or technical instruments, published between 2000 and 2025 in English, French, Portuguese or Spanish, addressing the organisation, delivery, workforce, technology, governance or financing of first-contact healthcare in a setting meeting the operational definition in Section 2.2. Sources whose subject matter lies outside health services were excluded, including engineering, manufacturing, educational and psychological literature that does not report health-service outcomes in a remote or isolated setting.

Table 2: Eligibility criteria.

Criterion	Included	Excluded
Setting	Populations and workforces meeting the operational definition of remoteness in Section 2.2 — rural, island, riverine, maritime and offshore.	Urban and peri-urban populations whose access barriers are primarily socioeconomic, organisational or intra-urban transport barriers; settings not satisfying both limbs of the operational definition.
Topic	Organisation, delivery, workforce, technology, governance, financing or infrastructure of first-contact or primary healthcare, including escalation and evacuation to definitive care.	Secondary or tertiary hospital care with no primary-care interface; clinical studies of specific therapies without a service-delivery dimension.
Subject area	Health services research, public health, occupational health, maritime medicine, health policy and health-system financing.	Literature outside health services, including engineering, manufacturing, energy systems, education and psychology, where no health-service outcome in a remote or isolated setting is reported.
Source type	Peer-reviewed empirical studies; systematic, scoping and integrative reviews; authoritative regulatory, normative and technical instruments issued by international organisations or national regulators.	Single case reports; conference abstracts without an accessible full text; editorials, commentaries and opinion pieces; unpublished theses and dissertations; predatory or unindexed outlets.
Language	English, French, Portuguese, Spanish.	All other languages, except where an authoritative English-language abstract or official translation is available for a normative instrument.
Date	1 January 2000 to [insert month] 2025.	Published before 2000, except where a source remains the operative normative instrument in its area (for example the

International Medical Guide for Ships and the Medical First Aid Guide) or provides the foundational denominator-based description of a service model for which no later equivalent exists.

2.6 Selection process

Records were de-duplicated in a reference manager. Titles and abstracts were screened against the eligibility criteria, and full texts of potentially eligible records were assessed. Screening was performed by [one/two] reviewer(s); where two reviewers screened, disagreements were resolved by discussion with a third. The flow of records include 127.

2.7 Data extraction and synthesis

Data were extracted into a matrix whose fields correspond to the columns of Tables 3 and 4: population and denominator served; first-line clinical capability; provider and required training; escalation and referral pathway; realistic time to definitive care; infrastructure dependencies; governing standard or regulation; and strength of supporting evidence. Synthesis proceeded in two stages. Sources were first coded thematically within each domain, producing the domain accounts in Sections 4, 5 and 6. The extraction matrix was then read across domains to identify mechanisms recurring in all three and features confined to one, which produced the comparative synthesis in Section 7. Where the evidence base for a cell was absent rather than merely weak, the cell is marked as such rather than inferred.

2.8 Appraisal of evidentiary strength

No formal risk-of-bias instrument was applied, since the included sources span trials, observational studies, qualitative research, programme evaluations and regulatory instruments, and no single instrument accommodates that range. Instead, each service model was assigned an explicit three-level rating of the strength of the evidence supporting it, reported in the final column of Table 4 and defined as follows. Strong: supported by randomised or controlled evidence, systematic review, or multi-country observational evidence with consistent findings. Moderate: supported by several single-setting evaluations, descriptive epidemiology with adequate denominators, or a well-specified normative instrument accompanied by some empirical evaluation. Limited: supported by single studies, descriptive accounts without denominators, or a normative instrument with no published evaluation of its effect. These ratings describe the evidence available for a model, not the quality of any individual study.

3. FOUNDATIONS OF REMOTE PRIMARY HEALTHCARE

3.1 Defining remote and isolated healthcare settings

Remote and isolated healthcare settings cannot be defined adequately by a single threshold of distance, population size or administrative status. In health-services research, remoteness is better understood as a relational condition in which spatial separation interacts with limited service availability, workforce scarcity, transport constraints and weak connectivity to higher levels of care. Early conceptual work in Australia distinguished remote health from conventional rural practice by emphasising geographical separation, restricted access to specialist resources, professional isolation, and the need for practitioners to operate with broader scopes of practice (Wakerman, 2004). Later Australian scholarship frames rural and remote health through the interaction of geographic isolation, local social relations, health-system structures and community responses; a settlement may therefore be geographically distant yet functionally well connected, while another may be comparatively closer to an urban centre and remain effectively isolated because transport, workforce or referral systems are inadequate (Bourke *et al.*, 2012).

The absence of a universal classification is evident in the United States, where multiple federal definitions employ different combinations of population, density, commuting relationships and metropolitan integration; these differences determine which communities are identified as underserved and therefore influence resource allocation, programme eligibility and the comparability of rural-health evidence (Childs, Boyas & Blackburn, 2022). Similar concerns arise in Ghana, where rurality has been argued to require context-sensitive indicators that move beyond a simple urban–rural dichotomy (Asante, 2021). African health systems illustrate why service capability must form part of the definition. In South Africa, rural healthcare has been characterised by limited ready access to specialist, intensive and high-technology care alongside shortages of human and material resources, which makes rurality a health-system condition as well as a geographical location: remoteness is experienced through restricted escalation pathways and constrained institutional capacity (Versteeg, du Toit & Couper, 2013). Nigerian evidence similarly demonstrates that rural primary-care facilities are differentiated not simply by location but by lower equipment readiness, longer travel times to administrative centres and weaker access to enabling infrastructure (Oyekale, 2017).

The concept becomes more distinctive at sea. Seafarers may spend prolonged periods beyond immediate physical access to physicians or hospitals, so isolation is determined by vessel position, voyage duration, communications capability, onboard competence and the feasibility of evacuation. Maritime healthcare therefore constitutes a mobile form of remoteness in which distance from definitive care changes continuously and clinical support may depend on telemedicine (Nittari *et al.*, 2019). Remote islands represent a related but territorially fixed form of separation; experience from Okinawa shows that island healthcare is shaped by the difficulty of maintaining physician supply and by the need for dedicated recruitment, training and retention mechanisms (Motomura, 2019). The term “isolated” should not be treated as synonymous with rural: isolation occurs in coastal, industrial and island environments that are not conventionally rural, while some rural communities maintain strong transport and digital links to regional centres. The operational definition adopted for this review, including its explicit exclusion criterion, is stated in Section 2.2.

3.2 Health inequalities across geographically isolated populations

Health inequalities among geographically isolated populations arise from the interaction of spatial disadvantage, socioeconomic deprivation, limited-service capacity and uneven exposure to the social determinants of health. Remoteness intensifies existing vulnerabilities by increasing travel costs, delaying care and narrowing access to preventive, diagnostic and specialist services. Evidence from rural Ethiopia demonstrates that longer distance and greater altitude difference between households and health facilities were associated with reduced utilisation of maternal services, while household wealth further differentiated access, illustrating how geography and socioeconomic position compound one another (Defar *et al.*, 2021).

Comparable inequities occur in remote riverine communities. In the Brazilian Amazon, rural populations face extensive travel distances, dependence on waterways and discontinuous access to organised primary care; fluvial mobile units improve physical reach, yet periodic delivery still constrains continuity for conditions requiring sustained management, showing that geographic inclusion requires more than episodic contact with providers (Garnelo *et al.*, 2020). Rural health inequalities are also evident in high-income settings: in the United States, shortages of clinicians, inadequate transportation, financial constraints and limited broadband availability restrict access and contribute to poorer outcomes than in urban populations (Douthit *et al.*, 2015). In India, substantial variation in the availability, qualifications, quality and cost of village-level providers indicates that proximity alone does not guarantee equitable primary care, since isolated communities may have providers present while encountering large differences in competence and service quality (Das *et al.*, 2022).

Isolated occupational populations exhibit a different but equally consequential inequality profile. Global survey evidence among seafarers links working conditions at sea — contract length, workload, rest and

social isolation — to wellbeing outcomes, indicating that the health disadvantage of maritime populations is generated by the conditions of the work as much as by distance from a hospital (Hayes-Mejia & Stafström, 2024). Commercial fishing represents the extreme case: current estimates place annual fisher deaths well in excess of 100,000 worldwide, three to four times higher than earlier assessments (Willis *et al.*, 2023), against which the health-service provision available to fishing crews is minimal (Section 4.5).

3.3 Principles of accessible remote healthcare delivery

Accessible remote healthcare delivery rests on the principle that geographical distance should not determine whether individuals receive timely, continuous and appropriate primary care. Accessibility requires more than placing facilities closer to populations: services must possess the workforce, medicines, equipment, referral capacity and organisational readiness needed to translate physical presence into effective care. Evidence from Enugu State, Nigeria, showed important gaps in service readiness, particularly in essential medicines, basic equipment and infrastructure, illustrating why availability without functional capacity cannot guarantee meaningful access (Ekenna *et al.*, 2020).

A second principle is integration. Remote populations benefit when preventive, maternal, child, chronic-disease and referral services are coordinated around the patient rather than delivered through fragmented programmes; experience from rural KwaZulu-Natal demonstrates that structured quality-improvement processes and integrated delivery can strengthen the range of services provided during primary-care encounters (Haskins *et al.*, 2019). Integration matters most where repeated travel imposes financial and logistical burdens.

Community proximity constitutes a third principle. Primary healthcare must be embedded within local social structures, using appropriately trained community-level personnel to extend prevention, basic treatment, surveillance and referral. India's long experience with village health workers shows both the potential and the governance challenges of community-based delivery, including the importance of adequate selection, training, supervision and system linkage (Strodel & Perry, 2019), and Brazilian evidence associates stronger community-health-worker activity with improved implementation of several primary-care functions (Santos *et al.*, 2020).

Continuity and predictability are equally fundamental. Visiting services can improve access in sparsely populated areas, but their effectiveness depends on regular scheduling, reliable communication, coordination with resident services, and relationships that preserve continuity between visits; a systematic review of Australian visiting models therefore emphasised guiding principles over rigid service typologies (Carey *et al.*, 2018). A recent review of outreach services for populations experiencing exclusion in high-income countries reaches a convergent conclusion, finding that outreach succeeds where it is integrated with, rather than parallel to, mainstream provision (Johnson *et al.*, 2025).

4. MARITIME AND OFFSHORE HEALTHCARE MODELS

Maritime healthcare is frequently treated in the literature as a single category. It is not. This section separates four configurations with materially different capability, staffing, governance and escalation characteristics — merchant shipping, passenger vessels and medical ships, fishing vessels, and fixed offshore installations — after first setting out the regulatory architecture that determines what onboard capability consists of. That architecture is the reason the four configurations differ, and it is the principal analytic feature distinguishing the maritime and offshore domains from the rural domain.

4.1 The regulatory architecture of care at sea

Healthcare aboard ship is not organised primarily by health systems. It is organised by labour and maritime safety instruments that attach to the flag State and to the shipowner, and any account of maritime service models that omits them describes practice without describing what determines it.

The governing instrument is the Maritime Labour Convention, 2006, as amended. Regulation 4.1 establishes seafarers' entitlement to medical care on board ship and ashore. Standard A4.1 gives that entitlement operational content: paragraph 4(b) requires a qualified medical doctor aboard ships carrying 100 or more persons and ordinarily engaged on international voyages of more than three days' duration; paragraph 4(c) requires ships without a doctor to carry either a seafarer in charge of medical care or a seafarer competent to provide medical first aid, trained to the standard of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers; and paragraph 4(d) requires States to ensure that medical advice by radio or satellite, including specialist advice, is available free of charge to all ships irrespective of flag, twenty-four hours a day (International Labour Organization, 2024). The 2022 amendments to the Code entered into force on 23 December 2024. Every Telemedical Maritime Assistance Service discussed below exists because of Standard A4.1(4)(d); the free, universal, round-the-clock character of that service is a legal guarantee, not a service-design choice, and it has no counterpart in any rural health system reviewed here.

What onboard capability consists of is defined by three further instruments. Regulation VI/4 of the STCW Convention, and Tables A-VI/4-1 and A-VI/4-2 of the STCW Code, set the standards of competence for seafarers designated to provide medical first aid and for those designated to take charge of medical care aboard ship (International Maritime Organization, 2017). The International Medical Guide for Ships, third edition, provides the clinical reference and the specification of the ship's medicine chest for vessels without a doctor (World Health Organization, 2007). The Medical First Aid Guide, adopted for use in accidents involving dangerous goods, supplies the chemical-casualty protocols (International Maritime Organization, World Health Organization & International Labour Organization, 1998). Together these define a first-line clinical capability delivered by a certificated non-clinician, working from a standard guide and a standard medicine chest, with a legally guaranteed line to a physician ashore. That configuration has no equivalent in land-based primary care.

4.2 Merchant shipping: certificated officer care with telemedical support

Merchant vessels ordinarily carry no clinician. First-line care is provided by a master or designated officer holding STCW VI/4 certification, and clinical decision-making is shared with a shore-based Telemedical Maritime Assistance Service (TMAS). This configuration must function across moving vessels, variable jurisdictions, unpredictable weather and considerable distances from definitive treatment, and it therefore combines preventive medicine, onboard first-line management, remote consultation, pharmaceutical stewardship and organised pathways for evacuation or port-based referral.

Preventive assessment is the first layer, because illness that appears manageable ashore may become clinically consequential during an extended voyage. Evidence from Benin identified hypertension, obesity and hearing impairment among seafarers undergoing fitness examinations, illustrating the value of systematic pre-embarkation screening and occupational risk assessment (Ayelo & Loddé, 2019). Medicine management is a persistent weakness: antibiotic self-medication among seafarers has been documented as a public health concern, demonstrating how prolonged separation from professional healthcare encourages inappropriate treatment and reinforcing the need for accessible clinical guidance and antimicrobial stewardship aboard (Adebisi *et al.*, 2021).

The TMAS link is the defining feature of the model. The Centro Internazionale Radio Medico (CIRM) in Rome holds the largest published TMAS dataset in the world; since 1935 it has assisted more than 81,000 patients and exchanged over half a million medical messages, and it was formally designated Italy's TMAS in 2002 (Mahdi & Amenta, 2016). Analyses of that dataset provide the most substantial descriptive epidemiology available for the model: a study of 423 medical contacts from 539 container ships over 2016–2019 characterised the balance of disease and injury presentations and their distribution by rank and department (Sagaro *et al.*, 2021), and a thirteen-year retrospective analysis of 793 injured seafarers aboard Italian-flagged ships extends that description across 2010–2022 (Sagaro & Amenta, 2025). A systematic review of TMAS practice across nine studies found teleconsultation to be the dominant service, delivered

principally by email and telephone, and identified connectivity and the digital divide between operators as recurrent constraints (Battineni *et al.*, 2023; see also Sagaro & Amenta, 2020).

Contemporary digital systems can structure symptom collection, transmit patient information and connect onboard personnel with shore-based clinicians. The Marine Doctor system illustrates how information and communication technologies can strengthen ship-to-shore interaction and reduce uncertainty surrounding clinical assessment (Battineni, Chintalapudi & Amenta, 2022), and a narrative review of maritime telemedicine requirements sets out the technical and organisational components on which such systems depend (Mohammadzadeh & Gholamzadeh, 2023). Experience during the COVID-19 period showed the importance of continuous communication with shore-based expertise, preventive information and systematic follow-up when normal access to port-based services is restricted (Sagaro *et al.*, 2020).

Escalation is the point at which the model is tested. Analysis of Turkish TMAS records showed that evacuation requirements were influenced by ship position, vessel and occupational characteristics, age, disease patterns and injury profiles, confirming that medical evacuation is a clinical and logistical decision rather than a transport response (Çakır, 2021). A recent scoping review of the medical causes of repatriation among commercial seafarers and offshore workers provides the only published comparison across two of the four maritime configurations examined here (Belliveau & Journeay, 2025). The CIRM series would allow a considerably larger cross-jurisdictional comparison than has yet been attempted.

4.3 Passenger vessels and medical ships: onboard physician-led facilities

Passenger vessels invert the merchant configuration. Under Standard A4.1(4)(b) of the MLC, a ship carrying 100 or more persons on international voyages exceeding three days must carry a qualified medical doctor, and large cruise vessels accordingly operate physician-led shipboard facilities with diagnostic, resuscitation and short-stay capability. By patient volume this is among the largest maritime primary-care settings in the world. The *de facto* facility standard is the American College of Emergency Physicians' health care guidelines for cruise ship medical facilities, first issued in 1995 and revised repeatedly since (American College of Emergency Physicians, 2023); it is an industry guideline rather than a binding instrument, which is itself an instructive contrast with the merchant configuration.

The descriptive evidence base is thin but has adequate denominators. A study of 196,171 passengers across 172 cruises recorded 7,147 physician encounters over more than 1.5 million passenger-days, of which some 11% were potentially life-threatening, with 203 medical disembarkations (Peake *et al.*, 1999). A prospective series aboard polar itineraries — the sub-type most relevant to this review — recorded 910 consultations over 205 days, with infectious disease predominating and evacuation from Antarctic waters proving practicable only once (Carron *et al.*, 2018). Medical ships extend the same physician-led configuration to shore populations rather than to those aboard: experience in Papua New Guinea demonstrates the importance of interprofessional communication, role clarity and collaborative practice when teams work in spatially constrained maritime environments, and shows that such vessels can function as mobile primary-care platforms reaching coastal populations where terrestrial transport is weak (Gustavsson *et al.*, 2021).

4.4 Fishing vessels: the least-served maritime population

Commercial fishing has the highest occupational fatality burden of any maritime sector and, by some measures, of any occupation. Current global estimates place fisher deaths well in excess of 100,000 per year, three to four times higher than previous assessments (Willis *et al.*, 2023); a review of fatal accident incidence found that rates remain far above land-based work despite substantial declines in northern Europe and North America following safety interventions (Jensen *et al.*, 2014); and national analysis confirms fishing as the most hazardous occupation in a high-income country (Roberts, 2010). Institutional assessments have long made the same point (Petursdottir, Hannibalsson & Turner, 2001).

Health-service provision to this workforce is nevertheless minimal and poorly evidenced. Crews are small, vessels are often below the tonnage and complement thresholds that trigger the MLC's medical-carer

requirements, communications may be limited, and the medicine chest and certificated carer arrangements described in Section 4.1 frequently do not apply. The governing instrument is the ILO Work in Fishing Convention, 2007 (No. 188), which addresses medical examination, medical care and medical supplies aboard fishing vessels (International Labour Organization, 2007); ratification remains uneven. A gap analysis of the health of fishers in the catching sector identified the absence of an evidence-based occupational health service and mapped the research required to build one (Matheson *et al.*, 2001); more than two decades later, that gap is substantially unclosed. This is the clearest and most consequential evidence gap identified by this review: the maritime population at greatest risk is the one about whose health services least is known.

4.5 Fixed offshore installations: the dedicated medic model

Fixed and floating offshore installations operate the most highly specified configuration reviewed here. A dedicated offshore medic is stationed on the installation, supported by a treatment facility, a telemedicine link to a physician ashore, and a helicopter medical evacuation pathway with defined response windows. In the United Kingdom the arrangement is statutory: the Offshore Installations and Pipeline Works (First-Aid) Regulations 1989 establish the duty (Great Britain, 1989); the Approved Code of Practice and guidance specify health care provision, medic competence and first-aider numbers (Health and Safety Executive, 2016); and the offshore medic qualification is approved and regulated by the Health and Safety Executive, with entry restricted to registered nurses, registered paramedics or qualified military medics and recertification required every three years (Health and Safety Executive, 2019). Comparable arrangements exist in the Norwegian sector, where the Activities Regulations specify the health service, its tasks, physician on-call arrangements, medicines and medical equipment, and communicable disease control (Norwegian Ocean Industry Authority, 2024), and in the Netherlands sector through industry standards on first aid and offshore medical evacuation (NOGEP, 2024).

Empirical evaluation of the model is thinner than its regulatory specification. Evidence from Niger Delta oil and gas platforms shows that medical emergency preparedness depends on trained personnel, accessible emergency equipment, clear response procedures and reliable evacuation arrangements, making preparedness a system-level requirement rather than an isolated clinical function (Dakpoko, Ugwoha & Wejie-Okachi, 2022). The offshore environment also generates distinctive public-health risks: a gastroenteritis outbreak on a Ghanaian drilling rig demonstrated how enclosed living arrangements, shared catering and workforce concentration facilitate rapid transmission, underscoring the importance of surveillance, infection prevention, food hygiene and prompt case management (Babayara & Addo, 2018). In European offshore wind operations, workers report physical strain, demanding schedules and psychosocial pressures, indicating that emergency support should be integrated with preventive occupational-health programmes rather than restricted to accident response (Mette *et al.*, 2018). The quality of the telemedical link that supports the medic remains inadequately standardised, as the scoping review of offshore telemedical quality indicators makes clear (Hellfritz, Waschkau & Steinhäuser, 2021), while a one-year offshore telemedicine emergency service evaluation illustrates what routine operation of such a link involves in practice (Mastella *et al.*, 2022).

5. RURAL AND REMOTE HEALTHCARE MODELS

5.1 Rural primary healthcare service configurations

Rural primary healthcare configurations must reconcile dispersed populations, workforce scarcity and limited referral capacity with expectations of continuous, comprehensive care. Effective configuration depends less on reproducing urban facility structures than on combining fixed primary-care sites, outreach, community-based personnel and referral networks in proportions suited to population density and travel constraints. Australian case-study analysis shows that viable rural systems may take the form of discrete services, integrated multidisciplinary models, comprehensive community-controlled care or hub-and-

spoke arrangements, and that effectiveness depends on the alignment of governance, funding, infrastructure, workforce and inter-service linkages (Wakerman *et al.*, 2009).

Nigeria's Midwives Service Scheme illustrates a clustered configuration designed around rural maternal and newborn care. Four primary healthcare facilities capable of basic obstetric services were linked to a secondary facility providing comprehensive emergency obstetric care, and additional midwives were deployed to underserved communities, strengthening the interface between first-contact care and referral; workforce retention and uneven subnational commitment constrained performance (Abimbola *et al.*, 2012). Community-oriented configurations extend care beyond facilities: in rural South Africa, ward-based outreach teams brought services closer to households through community health workers who connected residents with clinics and supported continuity across the household–facility interface (Khuzwayo & Moshabela, 2018), while Ethiopia's Health Extension Program positioned salaried health extension workers at village health posts, linked several posts to a health centre, and combined static services with household outreach in a tiered configuration (Assefa *et al.*, 2019).

Rural systems can also be reorganised through institutional integration. In China's Pengshui County, horizontal integration linked township and community health centres through shared governance and financing reforms, strengthening first-contact primary care and resource coordination in a low-resource setting (Zeng *et al.*, 2022). Mobile provision remains an important complement where fixed sites are impracticable, and recent economic analysis of a rural mobile clinic in the United States provides one of the few available accounts of its cost and time structure (Higgins, Tilghman & Lin, 2025). A systematic review of allied health service-delivery models in rural and remote Australia confirms both the diversity of configurations in use and the persistent thinness of comparative effectiveness evaluation across them (Brown *et al.*, 2025). Across these models, appropriate configuration is contingent on population scale, workforce distribution, community participation, referral distance and the capacity to integrate facility-based and outreach services into a coherent local network.

5.2 Community-based models for isolated populations

Community-based models address isolation by relocating selected primary-care functions from distant institutions into the environments in which people live. Their effectiveness depends on locally embedded personnel, community legitimacy, appropriate supervision, functional referral pathways and sufficient integration with formal services. Rather than replacing professional clinical care, these models create an intermediary layer through which prevention, health education, surveillance, basic case management and referral remain available where distance makes repeated facility attendance difficult. The normative framework for this layer is the World Health Organization guideline on health policy and system support to optimise community health worker programmes, which addresses selection, training, certification, supervision, remuneration, career pathways and integration into the health system (World Health Organization, 2018; Cometto *et al.*, 2018).

Nepal's Female Community Health Volunteer programme illustrates the model through a nationally established cadre delivering maternal and child health promotion, family-planning support and other community services; its experience demonstrates the capacity of locally recruited workers to connect households with formal services, while showing that expanding responsibilities require stronger training, incentives and system integration (Khatri, Mishra & Khanal, 2017). Rwanda relies extensively on community health workers, and evidence from the COVID-19 period showed their value in maintaining community-level services while revealing constraints involving protective resources, training, remuneration and increasing workloads (Niyigena *et al.*, 2022). A systematic review of rural community health worker effectiveness during the pandemic found consistent contributions to service continuity under system stress (Kaseje *et al.*, 2024), and regional analysis from South Asia documents the conditions under which community health workers sustain primary healthcare at scale (Shrestha *et al.*, 2024).

In remote Indigenous communities in northern Australia, Indigenous Health Workers employed as chronic-care coordinators linked clients with primary-care teams; their effectiveness depended not on geographical proximity but on role clarity, training, client engagement, management support and adequate

infrastructure, demonstrating that community-based models require institutional capacity behind the frontline worker (Schmidt *et al.*, 2016).

The model has a well-documented sustainability problem. A mixed-methods systematic review of community health worker workload in low- and middle-income countries found expanding task portfolios, transport burdens and inadequate remuneration to be recurrent and cumulative (Astale, Abebe & Mitike, 2023), and critical analysis of the WHO guideline itself argues that its framing understates the political and economic conditions on which programme viability depends (Nédee & Krumeich, 2025). Community-based delivery is therefore an intermediary layer that requires continuing investment, not a low-cost substitute for it.

6. ENABLING CONDITIONS

6.1 Workforce capacity, training and task sharing

Remote and isolated primary healthcare systems are constrained not only by worker shortages but by maldistribution, limited skill mix, professional isolation and inadequate opportunities for continuing development. Workforce capacity depends on matching competencies to local service needs while preserving safe escalation pathways. The term task sharing is used throughout this review in preference to task shifting, following current World Health Organization usage, and is defined as the redistribution of defined clinical activities to cadres with shorter or more focused preparation, under protocol, supervision and defined escalation. In low-income settings this redistribution expands service availability where physician supply is limited (Fulton *et al.*, 2011).

Evidence from rural northern Ghana shows that task sharing can partially compensate for staffing shortages, but that its effectiveness depends on clear role boundaries, supervision, appropriate training and recognition of additional frontline workloads; informal delegation otherwise pushes workers beyond their formal scope without corresponding support, threatening quality and morale (Okyere, Mwanri & Ward, 2017). South African evidence provides stronger experimental support: the STRETCH pragmatic cluster-randomised trial found that shifting aspects of antiretroviral treatment from doctors to trained primary-care nurses maintained important clinical outcomes while improving treatment access, demonstrating how structured delegation can extend professional capacity when supported by protocols (Fairall *et al.*, 2012). A Cochrane review found that appropriately trained nurses can provide several forms of primary care with outcomes comparable to, and sometimes better than, physician-led care, although uncertainty remains around costs and optimal training levels — reinforcing that delegation should rest on competency-based preparation, clinical governance and access to medical advice rather than on scarcity alone (Laurant *et al.*, 2018).

Retention is the other half of the problem. The World Health Organization guideline on health workforce development, attraction, recruitment and retention in rural and remote areas remains the operative normative guidance, setting out education, regulatory, financial and professional-support interventions (World Health Organization, 2021). Systematic review evidence supports rural-origin recruitment, substantial rural training exposure and professional development over coercive return-of-service mechanisms (Russell *et al.*, 2021), and a quantitative scoping review of allied health turnover in rural and remote areas confirms the pattern across a wider professional range (Cleland *et al.*, 2025). A five-year assessment of the Global Strategy on Human Resources for Health situates these findings within global workforce projections and policy direction (McIsaac *et al.*, 2024). Place-based governance that mobilises providers, communities, governments, educational institutions and local industries around retention offers a mechanism for acting on this evidence locally (Gillespie, Cosgrave & Malatzky, 2022), and a multi-country framework analysis has translated it into an organisational sequence of planning, recruitment and retention that remote services can operate directly (Abelsen *et al.*, 2020).

The maritime and offshore domains solve the same problem by a different route, and the contrast is instructive. Rather than recruiting and retaining a resident professional workforce, they certify a non-

clinician to a defined standard, equip that person with a standard guide and medicine chest, and guarantee access to a physician by telecommunication (Sections 4.1 and 4.5). Competence is maintained by mandatory periodic recertification — three-yearly for the UK offshore medic (Health and Safety Executive, 2019) — rather than by voluntary continuing professional development. Recertification tied to the right to hold the post is the mechanism that rural systems most conspicuously lack.

6.2 Telehealth, digital technologies and mobile services

Telehealth and digital technologies extend primary healthcare beyond the geographic limits of conventional facilities. In rural, maritime and offshore environments, virtual consultation, remote monitoring, mobile communication and digitally assisted decision-making connect isolated patients and frontline practitioners with expertise that would otherwise require costly or delayed physical transfer. These are not one technology but four, with different infrastructure requirements and different evidence bases: synchronous teleconsultation, which requires sustained bidirectional bandwidth; store-and-forward transmission, which tolerates intermittent connectivity and is consequently the dominant modality in low-connectivity and maritime settings; remote physiological monitoring, which requires devices, power and a receiving service; and clinical decision support, which can operate offline on a local device. Conflating them obscures why telehealth succeeds in some remote settings and fails in others. The World Health Organization classification of digital interventions, services and applications provides a shared vocabulary for making these distinctions consistently (World Health Organization, 2023a).

Across Africa, telemedicine has been identified as particularly relevant where shortages of specialists coexist with large travel distances, although weak infrastructure, unresolved regulatory issues and limited institutionalisation continue to constrain sustainable adoption (Mars, 2013). A systematic review and meta-analysis found that telehealth interventions delivered by nurses and allied health professionals produced outcomes broadly comparable with conventional care, supporting its use where distance restricts regular professional contact (Speyer *et al.*, 2018). Canadian experience in the Yukon demonstrates that telehealth can reduce patient travel and improve timely access, while highlighting the importance of clinician acceptance, appropriate workflows, current equipment and adequate technical infrastructure (Seto *et al.*, 2019). African experience with digital tools for community and primary health workers demonstrates opportunities to improve decision support, training, reporting and connections between peripheral workers and higher levels of care, alongside the constraints of unreliable connectivity, electricity deficits, limited digital competence and poorly adapted applications (Owoyemi *et al.*, 2022).

Post-pandemic evidence complicates the picture in an important way. Large-scale analysis of the United States telehealth expansion found that it did not degrade quality or access among Medicare beneficiaries (Saharkhiz *et al.*, 2024), and utilisation analysis of rural health clinics and federally qualified health centres documents how substantially rural safety-net provision came to depend on the emergency payment flexibilities (Jonk *et al.*, 2025). Those flexibilities are contingent, and rural telehealth volumes are therefore contingent on reimbursement policy rather than on clinical evidence. A scoping review of telehealth for rural and remote primary healthcare in high-income countries concludes that effectiveness depends on pre-existing clinician relationships and infrastructure rather than on the technology itself (Mathew *et al.*, 2025). The practical implication is that telehealth should be treated as a modality whose viability rests on three preconditions — payment, connectivity and an existing clinical relationship — rather than as a solution to distance.

Connectivity is the precondition most often assumed rather than measured. Empirical measurement of cellular network availability in sub-Saharan Africa found signal reliability, not clinician acceptance, to be the binding constraint on mobile health deployment (Siedner *et al.*, 2012), and analysis across 33 African countries shows that mobile phone ownership itself is unevenly distributed in ways that make some digital-health designs actively inequitable (Okano *et al.*, 2022). At sea the constraint takes a different form: satellite bandwidth is available but costly and variable, which is why store-and-forward email remains the dominant TMAS modality (Battineni *et al.*, 2023).

6.3 Energy, connectivity and infrastructure resilience

Electrical power is a clinical input in remote primary healthcare, not an ancillary service. Lighting for night-time obstetric care, refrigeration for vaccines and thermolabile medicines, sterilisation, oxygen concentration, laboratory and imaging equipment, and every form of digital connection described in Section 6.2 depend on it. The scale of the deficit is now well documented: a joint assessment by the World Health Organization, the World Bank, Sustainable Energy for All and the International Renewable Energy Agency estimates that around one billion people are served by health facilities with no electricity or an unreliable supply (World Health Organization *et al.*, 2023). Earlier systematic review of sub-Saharan African facility data found that, on average, only 28% of facilities in the reporting countries had a reliable supply (Adair-Rohani *et al.*, 2013). The World Health Organization has set out the minimum energy requirements by facility tier and the measurement problems that attend them in resource-constrained settings (World Health Organization, 2015).

The consequences for service delivery are measurable. Analysis of Indian primary health centres found a quantified association between under-electrification and reduced service provision (Shastry & Rai, 2021). Implementation research on solar electrification of rural primary care facilities in Ghana and Uganda found improvements in service availability and in staff retention and motivation, while establishing an important caveat: energy is necessary but not sufficient, and electrification alone does not produce service-delivery gains in the absence of commodities, staffing and supervision (Javadi *et al.*, 2020). Geospatial cost analysis indicates that decentralised renewable technologies are the least-cost route to universal electrification of rural healthcare facilities in sub-Saharan Africa (Moner-Girona *et al.*, 2021), and market analysis maps the financing and delivery-model landscape through which such electrification is actually procured (Sustainable Energy for All, 2024).

The vaccine cold chain is the clearest single illustration of the dependency. Solar direct-drive refrigeration was developed specifically as a response to inadequate or unreliable grid power in remote facilities (McCarney *et al.*, 2013); systemic cold chain weaknesses including power and equipment reliability remain widespread (Ashok, Brison & LeTallec, 2017); and facility-level assessment in northern Ethiopia documents the resulting variability in cold chain status and vaccine management at primary care level (Gebretnsae *et al.*, 2022). A cold chain failure is a clinical failure with a power cause, and it is invisible in most measures of service readiness.

Offshore installations solve the same problem by a different route — dedicated generation, redundancy and planned maintenance are integral to the installation rather than to the clinic — which is one reason offshore clinical capability is more consistently available than rural clinical capability at comparable distance from definitive care. That contrast is one of the clearest findings of this review, and it is a design finding rather than a resource finding: rural facilities are rarely designed with the power redundancy that an offshore medical facility takes for granted. Climate change sharpens the requirement in both domains, and the World Health Organization guidance on climate-resilient and environmentally sustainable health care facilities identifies sustainable energy services as one of four fundamental requirements for facility resilience (World Health Organization, 2020).

7. COMPARATIVE SYNTHESIS

This section delivers the comparison the review was designed to make. Tables 3 and 4 set the nine service configurations identified across the three domains against a common extraction framework: Table 3 covers population, capability and provider; Table 4 covers escalation, dependencies, governance and evidentiary strength. Table 5 reports the geographic coverage of the included evidence. The two subsections that follow state what the comparison yields: the mechanisms that recur across all three domains, and the features that are specific to one and should not be transported to another.

Table 3: Comparison of remote primary healthcare service models: population, first-line capability and provider.

Service model		Domain	Population and denominator served	First-line clinical capability	Provider and required training
Fixed primary healthcare facility	rural	Rural	Defined geographic catchment, commonly 2,000–30,000 permanently domiciled residents; denominator is the catchment population, demographically complete.	Comprehensive first-contact care: maternal, newborn and child health; immunisation; chronic disease management; basic emergency stabilisation. Capability is contingent on service readiness rather than on designation.	Nurses, midwives and community health extension workers; physicians in some systems. Pre-service professional qualification with in-service supervision; recertification uncommon.
Scheduled outreach and visiting services		Rural	Satellite communities beyond the catchment of a fixed facility; denominator frequently undefined, which limits evaluation.	Episodic preventive care, screening, minor treatment and review of stable chronic conditions. No capability between visits.	Visiting clinicians and multidisciplinary teams travelling from a base facility; same qualifications as the base service.
Mobile and fluvial clinics		Rural	Dispersed, riverine or seasonally inaccessible populations without practical access to a fixed site; denominator estimated rather than enumerated.	Preventive care, screening, minor treatment and referral initiation; limited on-board diagnostics; cold chain carried with the unit.	Mobile team, commonly nurse-led, occasionally physician-led; standard professional qualification plus operational training for the platform.
Community health worker and village-based models		Rural	Household or village catchment, commonly 50–250 households per worker; denominator enumerated by household registration.	Health promotion, screening, integrated community case management, maternal and newborn support, surveillance and referral; scope defined by protocol.	Locally recruited community health workers or volunteers; short competency-based training with supervision, remuneration and career pathway as specified by WHO guideline.
Hub-and-spoke and clustered configurations		Rural	Aggregated catchments of several first-level facilities linked to one referral hub; denominator is the sum of spoke catchments.	Graded: basic first-contact and basic emergency obstetric care at spokes; comprehensive emergency capability at the hub.	Mixed cadres at spokes, with midwives or nurses deployed to underserved nodes; specialist capability held at the hub.
Merchant shipping: certificated officer with telemedical support		Maritime	Crew of a single vessel, commonly 15–25 persons; denominator is the crew complement and exposure is measured in voyage days.	Medical first aid and medical care to the STCW standard, delivered from the ship's medicine chest using the International Medical Guide for Ships; clinical judgement shared with a shore physician.	Master or designated officer holding STCW regulation VI/4 certification — a certificated non-clinician. Proficiency is revalidated at intervals set by the flag State.
Passenger vessels and medical		Maritime	Passengers and crew, from several hundred to several thousand; among the	Physician-led facility with diagnostics, resuscitation, minor procedures, pharmacy	Physicians and nurses employed aboard;

ships: onboard physician-led facility		largest maritime primary-care denominators by encounter volume.	and short-stay beds; capability approaching a small emergency department.	qualifications set by the operator against industry guidelines rather than by binding instrument.
Fishing vessels	Maritime	Small crews, commonly 3–20; the maritime workforce with the highest fatality burden and the least characterised denominator.	Minimal. Many vessels fall below the thresholds triggering a certificated medical carer or a standard medicine chest.	A crew member with basic training or none. Provision is uneven and governed by an instrument with incomplete ratification.
Fixed offshore installations: dedicated medic	Offshore	Installation complement, commonly 50–300; a closed, enumerated and occupationally pre-screened working-age cohort.	Dedicated treatment facility with defibrillation, oxygen, controlled drugs, immobilisation and a telemedicine link; the most consistently available first-line capability of any model reviewed.	Offshore medic — a registered nurse, registered paramedic or qualified military medic, approved by the national regulator, with mandatory recertification (three-yearly in the United Kingdom).

Table 4: Comparison of remote primary healthcare service models: escalation, dependencies, governance and evidentiary strength.

Service model		Escalation and referral pathway	Realistic time to definitive care	Infrastructure dependencies	Governing standard or regulation	Evidence
Fixed primary healthcare facility	rural	Ground referral to a district or secondary facility; ambulance where available, private or informal transport where not.	Hours; highly variable with terrain, transport availability and season.	Building, power, water, cold chain, commodity supply chain, road access, connectivity.	National primary healthcare policy; facility accreditation and service-readiness standards. No international instrument.	Strong. Multi-country observational and facility-assessment evidence; trial evidence on financing.
Scheduled outreach and visiting services		Transfer to the base facility; interval care depends on a local worker or on self-management.	For non-urgent care, a function of the visit cycle; for emergencies, unchanged from no service at all.	Vehicles or aircraft, roads or airstrips, scheduling systems and communications.	Service-level policy and programme protocols. No international standard.	Moderate. Systematic review of guiding principles rather than of comparative effectiveness.
Mobile and fluvial clinics		Referral to a fixed facility; the transport asset delivering care is	Constrained by waterway and road conditions	Vessel or vehicle, fuel, maintenance,	Programme protocols, public or non-governmental. No international standard.	Moderate. Observational service

	often the same asset required for transfer.	and by seasonality; may exceed that of a fixed facility.	on-board cold chain and power.		evaluations and one recent cost and time-motion analysis.
Community health worker and village-based models	Referral to a facility; the pathway depends on the worker recognising the escalation trigger.	Unchanged for definitive care — distance decay persists despite community-level provision.	Commodities, supervision structure, mobile connectivity, incentives and remuneration.	WHO guideline on community health worker programmes (2018); national community health worker policy.	Strong. Normative guideline, systematic reviews and multi-country programme evidence.
Hub-and-spoke and clustered configurations	Defined intra-cluster referral to a named hub with comprehensive emergency capability.	Shortened by design; contingent on inter-node transport and on hub readiness.	Transport between nodes, communications, shared governance and pooled financing.	National scheme rules and health-system integration or financing reform.	Moderate. Programme evaluations; workforce retention and subnational commitment are recurrent failure modes.
Merchant shipping: certificated officer with telemedical support	Telemedical consultation with a shore-based service, leading to onboard management, diversion, port call or medical evacuation.	Hours to days; a continuously varying function of position, weather and helicopter range.	Satellite communications, medicine chest, electrical power, refrigeration.	MLC 2006 Regulation 4.1 and Standard A4.1; STCW regulation VI/4 and Code section A-VI/4; International Medical Guide for Ships; Medical First Aid Guide.	Moderate. Substantial descriptive epidemiology from TMAS case series; no comparative effectiveness evidence.
Passenger vessels and medical ships: onboard physician-led facility	Port call, shoreside referral, disembarkation or evacuation; onboard capability resolves most presentations.	Hours; extended on polar and other remote itineraries where evacuation may be impracticable.	Shipboard clinic, equipment, pharmacy, power, laboratory and imaging capability.	MLC Standard A4.1(4)(b) for the physician requirement; ACEP health care guidelines for cruise ship medical facilities as the industry standard.	Moderate. Descriptive epidemiology with large denominators, but little recent evidence.

Fishing vessels	Telemedical assistance where accessible; return to port; search and rescue services.	Frequently the longest of any model reviewed — small vessels, long transits, limited communications.	Often absent: limited communications, no medicine chest to the international standard on smaller vessels.	ILO Work in Fishing Convention, 2007 (No. 188) on medical examination, medical care and medical supplies; ratification uneven.	Limited. Strong mortality data; almost no service-delivery evidence. The principal gap identified by this review.
Fixed offshore installations: dedicated medic	Physician support by telemedicine, then helicopter medical evacuation within a defined and rehearsed response window.	Typically within a few hours in well-regulated sectors; weather-dependent and occasionally prolonged.	Helideck, communications, dedicated and redundant power, treatment facility, emergency response organisation.	National statutory regimes: SI 1989/1671 with HSE Approved Code of Practice L123 and MS39 (UK); Activities Regulations §§8–12 (Norway); industry standards 010 and 013 (Netherlands).	Moderate. Regulatory architecture well specified; peer-reviewed evidence of service outcomes is thin.

Table 5: Geographic coverage of the included evidence.

Region	Countries and territories represented	Sources (n)	Predominant evidence type
Sub-Saharan Africa	Nigeria, Ghana, South Africa, Ethiopia, Kenya, Madagascar, Rwanda, Uganda, Benin; multi-country	30	Facility assessments, geospatial accessibility analysis, programme evaluation, one large randomised trial of financing
Europe	United Kingdom, Ireland, Italy, Germany, Norway, Netherlands, Nordic region	22	Regulatory instruments, telemedical service case series, occupational health studies
Oceania	Australia, Papua New Guinea	12	Service typologies, systematic reviews, workforce retention studies, qualitative evaluation
North America	United States of America, Canada	13	Access barrier analysis, telehealth evaluation, descriptive epidemiology, health-system commentary

Asia	India, Nepal, Indonesia, China, Japan; South Asia regional	8	Provider quality studies, community health worker programme evaluation, integration reform
Latin America and the Caribbean	Brazil, Haiti	5	Integrative review, riverine service evaluation, accessibility measurement
Middle East, North Africa and Türkiye	Türkiye, Iran	2	Telemedical assistance service analysis, narrative review
Global, multi-region and normative	International instruments and multi-country syntheses	35	Conventions, codes and guidelines; systematic reviews; global assessments
Total		127	

Note. Sources addressing more than one country are assigned to the region of their principal setting; international conventions, codes, guidelines and multi-region syntheses are counted once under “Global, multi-region and normative”. The concentration of rural evidence in Australia, Nigeria, Brazil and South Africa, and of maritime evidence in Italy, is discussed in Section 9.

7.1 Mechanisms that recur across all three domains

Reading Tables 3 and 4 across rather than down identifies six mechanisms present in every configuration that functions, irrespective of domain. These, rather than the models themselves, are what transfers.

- A competent first-line responder positioned inside the isolated unit, whose scope is set by protocol rather than by profession. The community health worker, the STCW-certificated officer and the offshore medic are the same design element expressed through three different labour markets. In each case the decisive variables are the clarity of the protocol, the adequacy of supervision and the definition of the escalation trigger — not the underlying professional qualification (Fulton *et al.*, 2011; Okyere, Mwanri & Ward, 2017; International Maritime Organization, 2017; Health and Safety Executive, 2016).
- A guarantee of access to distant clinical expertise, held at system level rather than service level. The maritime domain expresses this as a legal entitlement to free, universal, round-the-clock telemedical advice (International Labour Organization, 2024); rural systems express it, where they express it at all, as a programme or a project. The evidence that telehealth works in rural settings is reasonably good (Speyer *et al.*, 2018; Mathew *et al.*, 2025); the evidence that it is reliably available is not, and the difference is a governance difference rather than a technological one.
- A pre-defined and resourced escalation pathway with a named destination and an identified owner of the transfer decision. Where this is specified in advance — the offshore MEDEVAC window, the hub of a hub-and-spoke cluster — escalation is a clinical decision. Where it is not, it becomes a logistics negotiation conducted during an emergency (Abimbola *et al.*, 2012; Çakir, 2021; Dakpokpo, Ugwoha & Wejie-Okachi, 2022).
- Continuity of the clinical record across the escalation boundary. This is the weakest element in every domain examined. The seafarer evacuated to a foreign port, the villager referred to a district hospital and the offshore worker repatriated across a national border share the same problem: the clinical account of what was done before transfer is frequently lost at the boundary (Sagaro *et al.*, 2020; Belliveau & Journeay, 2025).
- Electrical power and communications treated as clinical infrastructure rather than as facilities support. Section 6.3 sets out the rural evidence; the offshore sector reaches the same conclusion by designing redundancy into the installation. The domains differ in whether this is recognised, not in whether it is true (World Health Organization *et al.*, 2023; Javadi *et al.*, 2020).
- Periodic recertification tied to the right to hold the post. The offshore medic recertifies every three years or ceases to be an offshore medic (Health and Safety Executive, 2019); STCW certificates of proficiency are likewise revalidated at intervals set by the flag State (International Maritime Organization, 2017). Community-based and rural cadres are typically supervised but not recertified, and this is the single most transferable feature of the maritime and offshore models.

7.2 Features that do not transfer

Six features are specific to their domain, and treating them as generalisable is the most common error in the cross-domain literature.

- The logic of the population denominator. Rural catchments are open, permanently domiciled and demographically complete. Maritime and offshore populations are closed, enumerated, occupationally screened cohorts with a known exposure period. Pre-embarkation screening

removes morbidity before exposure (Ayelo & Loddé, 2019); no rural system can screen its population before admitting it. Comparative performance figures that ignore this difference are not comparable.

- The demand profile that follows from it. Offshore and merchant populations are predominantly working-age, male and pre-screened, presenting with injury, acute infection and occupational conditions. Rural catchments carry maternal and newborn care, paediatrics, and chronic multimorbidity across the life course (Defar *et al.*, 2021; Das *et al.*, 2022). A service model optimised for one demand profile is not evidence for the other.
- The source of regulatory leverage. Maritime and offshore capability is set by binding instruments attached to the flag State or the employer and can be raised by amending an instrument — as the 2022 amendments to the MLC Code demonstrate. Rural capability is set by public budgets and competes with every other public claim. This asymmetry explains why the offshore worker 200 kilometres from shore may have more reliable first-line care than the villager 60 kilometres from a district hospital, and it is not a transferable design feature.
- The stability of time-to-definitive-care. For a rural community this is a parameter that can be measured, modelled and planned against (Moturi *et al.*, 2022; Bhangdia *et al.*, 2022). For a vessel underway it is a continuously varying function of position, weather and helicopter range, which is why maritime systems invest in decision support for the evacuation judgement rather than in reducing the interval itself (Çakir, 2021).
- Community participation. Community legitimacy, local recruitment and participatory governance are central to the effectiveness of rural and community-based models (Kushitor *et al.*, 2019; Khatri, Mishra & Khanal, 2017) and are largely inapplicable to a transient occupational cohort assembled by contract for a single voyage or rotation.
- The identity of the cost-bearer. Maritime and offshore healthcare is an employer cost internal to a commercial operation, which is why its standards can be raised by regulation without a public budget decision. Rural healthcare is a public cost. Financing evidence therefore transfers only within domains: the Nigerian trial comparing decentralised facility financing with performance-based payment (Khanna *et al.*, 2021) has no offshore analogue, and offshore capability standards have no rural funding mechanism.

7.3 What the comparison implies

Two conclusions follow. First, the frequent claim that no single service model is universally transferable is supported by the evidence assembled here, but it is imprecise. What the comparison suggests is that transferability operates at the level of mechanism rather than of model: the six mechanisms in Section 7.1 recur wherever remote care works, while the models that carry them are shaped by denominator logic, demand profile, regulatory leverage and cost-bearer, none of which travel. Attempts to import a model wholesale — a maritime telemedicine architecture into a rural district, or a community health worker cadre onto a merchant vessel — fail on those four dimensions rather than on the mechanism.

Second, the direction of useful transfer is not symmetrical. The maritime and offshore domains have solved two problems that rural systems have not: a legally guaranteed, universally available line to distant clinical expertise, and recertification tied to the right to practise. The rural domain has solved two problems the maritime domain has barely addressed: continuity of care for chronic conditions, and community legitimacy. The most promising cross-domain learning identified by this review runs in both directions along those specific lines, and not along the technological ones on which the literature has principally focused.

8. STRENGTHENING REMOTE PRIMARY HEALTHCARE SYSTEMS

8.1 Governance, financing and cross-sector coordination

Governance, financing and cross-sector coordination constitute the institutional architecture through which remote primary healthcare becomes sustainable rather than episodic. Governance must clarify authority across national ministries, subnational administrations, facility managers, emergency services, transport providers, community organisations and, in the maritime and offshore domains, flag States and commercial operators. Ghanaian evidence shows that primary healthcare implementation is distorted when policy expectations, managerial interpretation and external stakeholder priorities diverge, highlighting the need for coherent accountability, locally responsive decision-making and better alignment between funders and implementing institutions (Appiah-Agyekum, 2020).

Financing arrangements are equally consequential, because isolated services face higher unit costs arising from transport, workforce incentives, communications, outreach and low patient volumes. The most directly policy-actionable empirical finding identified by this review comes from a large-scale randomised controlled trial in Nigeria comparing decentralised facility financing with performance-based payment across primary health care facilities (Khanna *et al.*, 2021). Both approaches improved service utilisation and several quality indicators relative to business-as-usual. The finding of principal interest for remote systems is that decentralised facility financing achieved gains comparable to performance-based payment for many outcomes at substantially lower funding intensity, and did so through a simpler administrative mechanism: predictable resources placed at facility level, combined with managerial autonomy, supervision and community engagement. Performance-based payment requires verification infrastructure — measurement, audit and dispute resolution — that is costly to operate precisely where facilities are dispersed and supervisory visits are expensive. For remote settings the trial therefore supports predictable facility-level financing with autonomy over activity-based incentives, and it does so on the strongest study design available in this literature. Its principal limitation for present purposes is that it was conducted in a single country and did not stratify results by remoteness, so the differential effect in the most isolated facilities is not directly reported.

Cross-sector coordination matters wherever healthcare depends on capabilities located outside the health sector. Experience with the United Kingdom's Local Improvement Finance Trust demonstrates that public-private partnership structures do not automatically produce effective collaboration: trust, governance arrangements, fiduciary incentives and the balance of control between partners shape whether joint infrastructure initiatives serve public objectives (Agyenim-Boateng, Stafford & Stapleton, 2020). The lesson applies directly to remote healthcare, where aviation or marine transport, telecommunications, energy providers, local government and private employers collectively determine whether patients can be reached, stabilised and referred. In the offshore domain that coordination is contractually specified within a single operation; in the rural domain it must be negotiated across independent institutions, which is why it fails more often.

8.2 Strategic priorities and future research directions

Future development of primary healthcare in maritime, offshore and rural settings requires a shift from fragmented responses to deliberately designed systems capable of maintaining access despite distance, workforce scarcity, infrastructure failure and environmental disruption. Five priorities follow from the synthesis in Section 7.

Place-sensitive workforce development. Recruitment incentives alone are unlikely to produce durable capacity unless accompanied by locally appropriate training pathways, professional

support, career development, family integration and community participation, and place-based governance offers a mechanism for organising these locally (Gillespie, Cosgrave & Malatzky, 2022; World Health Organization, 2021). The specific proposal arising from this review is that rural systems examine periodic recertification tied to scope of practice, on the offshore model, as a means of sustaining delegated clinical capability.

Digital transformation with its preconditions costed. Future research should move beyond short pilot projects toward longitudinal evaluations examining clinical outcomes, equity, interoperability, affordability, workforce workload and sustainability at scale (Owoyemi *et al.*, 2022), and should report connectivity and power availability as measured variables rather than as assumptions (Siedner *et al.*, 2012; Okano *et al.*, 2022). Emerging guidance on the governance of artificial intelligence in health will require the same treatment as it enters remote practice (World Health Organization, 2024).

Maritime telemedical assistance as an integrated service rather than a reactive one. Research priorities should include internationally comparable indicators for telemedical quality, diagnostic reliability, response time, clinical escalation, evacuation decisions and continuity of medical records across jurisdictions (Sagaro *et al.*, 2020; Battineni *et al.*, 2023; Hellfritz, Waschkau & Steinhäuser, 2021). The CIRM dataset makes a multi-decade, cross-jurisdictional evaluation feasible, and it has not been attempted.

Healthcare for fishing fleets. This review identifies commercial fishing as the maritime sector with the highest fatality burden and the least service-delivery evidence (Section 4.4). Closing that gap requires basic descriptive work: what medical capability fishing vessels actually carry, what proportion of the global fleet falls within the scope of ILO Convention No. 188, what use fishing crews make of TMAS, and what the outcomes of maritime evacuation from fishing vessels are. None of these questions currently has a published answer of adequate quality.

Climate resilience and energy security. Remote clinics, mobile facilities and offshore medical units depend on uninterrupted power for communications, refrigeration, diagnostics and monitoring, and climate change is increasing both demand and disruption. The World Health Organization operational framework for climate-resilient and low-carbon health systems provides the planning structure (World Health Organization, 2023b), and a scoping review of health-system adaptation maps the current global evidence and its gaps (Ansah *et al.*, 2024). Work on the effects of climate on remote service delivery itself remains scarce; analysis of aeromedical retrieval in northern Australia is a rare example of a study addressing a remote delivery model directly (Quilty *et al.*, 2024), and evidence on extreme heat among older regional and rural populations indicates the demand-side pressure that will accompany it (Harvey, Bain-Donohue & Dewi, 2024).

Underlying all five is a structural inequity that service design alone cannot resolve. Canadian experience demonstrates that universal financial coverage does not itself eliminate the consequences of vast geography, uneven workforce distribution and dependence on medical transport for isolated communities (Martin *et al.*, 2018). Future service design should evaluate hybrid configurations combining local generalist capacity, expanded professional scopes, telehealth, regional referral networks and culturally responsive care, and should measure whether innovations reduce disparities rather than merely increase service activity.

9. LIMITATIONS

Several limitations qualify the conclusions of this review.

- This is a structured narrative review, not a systematic review. Although the search was specified in advance and is reported in full, retrieval was not exhaustive, and screening was

not duplicated throughout. Some eligible literature will have been missed, and the possibility of selection bias in favour of sources known to the authors cannot be excluded.

- No formal risk-of-bias appraisal was undertaken. The three-level rating of evidentiary strength reported in Table 4 describes the collective evidence available for each service model, not the internal validity of individual studies, and it involves judgement that another reviewer might exercise differently.
- Language restriction to English, French, Portuguese and Spanish introduces probable bias. Substantial maritime health literature is published in Italian, Japanese, Chinese, Norwegian and Polish, and the Okinawa island-health source relied on here is available only in Japanese (Motomura, 2019), so the English-language framing of remoteness is likely to be over-represented.
- The included evidence is geographically concentrated. As Table 5 shows, Australia, Nigeria, Brazil and South Africa contribute disproportionately to the rural evidence, and Italy contributes disproportionately to the maritime evidence through the CIRM series. Conclusions about what transfers across settings are therefore shaped by the health systems that happen to publish, and the absence of evidence from large remote populations in Central Asia, the Pacific and the Arctic is a real gap rather than an artefact of searching.
- The comparison in Tables 3 and 4 is constructed from heterogeneous sources rather than from a common dataset. Cells describing regulatory requirements are drawn from binding instruments and are accurate as statements of what is required; cells describing realistic time to definitive care are estimates synthesised from descriptive literature and operational guidance, and should be read as indicative rather than measured. No study reports these parameters comparably across domains, which is itself a finding.
- Evidence on service delivery to fishing fleets is too sparse to support the same depth of analysis applied to the other configurations, and the corresponding rows of Tables 3 and 4 rest substantially on regulatory text rather than on evaluation.
- The literature search closes in 2025 and the field is moving, particularly in relation to telehealth reimbursement policy, the implementation of the 2022 amendments to the MLC Code, and the governance of artificial intelligence in clinical decision support.

10. CONCLUSION

The delivery of primary healthcare across geographically remote and operationally isolated environments is shaped by the interaction of distance, workforce availability, infrastructure reliability, governance capacity, financing arrangements, technological connectivity and community context. By setting maritime, offshore and rural configurations against a common extraction framework, this review identifies both the structural challenges they share and the mechanisms through which access is sustained where conventional facility-centred systems are insufficient.

The evidence assembled indicates that no single service model is universally appropriate, and suggests more specifically that transferability operates at the level of mechanism rather than of model. Six mechanisms recur wherever remote care functions: a protocol-defined first-line responder inside the isolated unit; a system-level guarantee of access to distant expertise; a pre-defined and resourced escalation pathway; continuity of the clinical record across the escalation boundary; power and connectivity treated as clinical infrastructure; and recertification tied to the right to hold the post. Six features do not transfer, because they are determined by the denominator logic, demand profile, regulatory leverage and cost-bearer of each domain.

Across all settings, workforce shortage remains the fundamental constraint, which makes competency-based training, multidisciplinary practice, professional support and carefully governed task sharing essential. Digital technologies can reduce professional isolation and improve continuity, but their effectiveness rests on reliable electricity, telecommunications, interoperability, data security and payment arrangements, and on integration with physical care pathways rather than substitution for them. Community-based approaches strengthen accessibility by embedding services within local social structures, at the cost of a continuing investment in supervision and remuneration that is frequently underestimated.

Sustainable remote healthcare requires governance extending beyond the health sector: financing, transport, energy, telecommunications, emergency services, community institutions and, at sea, flag States and commercial operators must be coordinated through clear accountability structures. Policymakers should accordingly prioritise place-sensitive service design, stable workforce pipelines, resilient infrastructure, integrated telehealth, predictable facility-level financing and strengthened referral systems. Future research should employ comparative longitudinal designs, standardised accessibility indicators, cost-effectiveness evaluation and patient-centred outcome measures across rural, island, maritime and offshore populations, and should address the health services available to commercial fishing crews, which this review identifies as the largest and most consequential evidence gap in the field.

Data availability

All data underlying this review are contained within the cited published literature and the regulatory instruments listed in the References.

Ethics approval

Not applicable. This review analyses previously published literature and publicly available regulatory instruments, and involved no human participants, human tissue or personal data.

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