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Regional Composition and Population-Adjusted Distribution of Radiologists and Radiographers in Saudi Arabia: A National Ecological Analysis

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Abstract

Background/Objectives: This national ecological study compared the regional distribution and composition of the radiologist and radiographer workforces in Saudi Arabia. **Methods:** Published registry headcounts were compiled for 13 administrative regions, with densities calculated using the 2022 Census. We compared headcounts, densities and radiographer-to-radiologist ratios and assessed sensitivity to unassigned records. **Results:** Headcounts were more strongly correlated than densities (Spearman $\varrho = 0.967$ vs. 0.313). The partial headcount correlation adjusted for population was 0.573. Regional analyses included 4800 of 5150 radiologists and 20,165 of 22,626 radiographers. The median regional ratio was 4.38 (interquartile range, 3.64–5.02); the aggregate ratio among region-assigned records was 4.20. Radiographer density showed greater regional variation (coefficient of variation, 32.7% vs. 15.4%; Gini coefficient, 0.167 vs. 0.084). **Conclusions:** Headcounts and population-adjusted densities describe different aspects of workforce distribution. These measures can guide follow-up assessments but do not establish staffing adequacy.

Keywords: radiologists; radiographers; health workforce; workforce planning; geographic distribution; Saudi Arabia

1. Introduction

Diagnostic imaging is central to disease detection, treatment planning, image-guided intervention, and follow-up across medical specialties [1–5]. Its safe and effective delivery depends on coordinated multidisciplinary practice, including radiologists, who provide clinical interpretation and image-guided expertise [4–6], and radiographers, who perform examinations, operate increasingly complex imaging technologies, and contribute to patient safety and multidisciplinary care [1,5,7]. Longitudinal data from seven United States (US) healthcare systems and Ontario showed increasing use of computed tomography (CT) and magnetic resonance imaging (MRI) among adults and older adults between 2000 and 2016, although growth slowed over time [8]. Workforce planning must therefore consider professional supply, geographic distribution, and composition of complementary professional groups [9–11].

Radiologists are medically qualified physicians who undertake postgraduate specialty training in radiology; their roles include image interpretation, clinical consultation and image-guided procedures [4]. In the Saudi national registry study, consultants (35.0%), registrars (29.7%), and senior registrars (22.7%) were the three largest professional ranks. Diagnostic radiology was the predominant registered specialty (83.7%); smaller groups

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were registered in body imaging, diagnostic neuroradiology, musculoskeletal radiology, and interventional radiology [12].

Radiographers acquire diagnostic images, operate imaging equipment, and ensure patient safety during examinations [7]. In the Saudi registry study, 52% held a bachelor's degree, 43% a diploma, and 5% postgraduate qualifications or board certification. Specialists (52.5%) and technicians (43.9%) were the largest professional categories [13]. International studies have described geographic maldistribution and differences in education and staffing capacity [14–16].

Workforce maldistribution concerns both where professionals work and whether their skills match local service needs. Radiologists and radiographers often perform complementary tasks. The extent to which responsibilities can be shared depends on training, credentialing, scope of practice, and local service organisation [10,11].

Saudi Arabia is reforming its healthcare system through the Health Sector Transformation Program (HSTP) under Vision 2030, with priorities that include access, quality, integration, digital transformation, workforce development, and localisation [17]. This study jointly describes previously published data on both professions across the 13 administrative regions. Its contribution is a comparison of existing data, rather than the development or validation of a measurement instrument. The objectives were to compare regional headcounts, population-adjusted densities, geographic variation, and radiographer-to-radiologist ratios.

2. Materials and Methods

2.1. Study Design and Data Sources

This was a national ecological analysis of published aggregate workforce data. The administrative region was the unit of analysis; no individual-level records were obtained, linked, or analysed. Data came from two peer-reviewed national cross-sectional studies based on Saudi Commission for Health Specialties (SCFHS) registry records. The extracts covered radiologists on 3 August 2025 [12] and radiographers on 11 September 2025 [13], 39 days apart. SCFHS confirmed that both extracts used the same eligibility definition for registered professionals practising in Saudi Arabia, despite differences in the published descriptions. Both studies reported counts across the same 13 administrative regions (Figure 1).



Figure 1. Administrative regions of Saudi Arabia included in the analysis. Administrative boundary data were obtained from geoBoundaries [18].

The published counts represent individuals, not full-time equivalents (FTEs). Regional assignment reflects recorded employment region, not licence issuance. The radiologist study included residents and residents-in-training, and the radiographer study included trainee specialists. Part-time inclusion was not specified for radiologists. The radiographer study excluded part-time registrants whose employment could not be confirmed but did not report how many part-time practitioners were retained.

For each region, published radiologist and radiographer counts were extracted. Records with an unknown or other location were retained in national totals but excluded from the primary regional analysis (Appendix Figure A1). Exact regional population denominators were obtained from the Saudi Census 2022 [19,20]. The 13 regional counts summed to 32,175,224. The calculated densities represent 2025 registered workforce counts standardised to the 2022 Census population rather than contemporaneous 2025 rates. The Census provided a common, exact regional baseline; the densities are not estimates of contemporaneous 2025 availability.

2.2. Outcome Measures

The primary outcome was the regional radiographer-to-radiologist ratio:

$$\mathrm{RR}_i = \frac{T_i}{R_i} \tag{1}$$

where T_i is the number of radiographers and R_i is the number of radiologists in region i. The overall national ratio used all records reported by the source studies. The aggregate region-assigned ratio used only professionals assigned to one of the 13 regions. Regional ratios were analysed as continuous values and compared descriptively with the aggregate region-assigned ratio.

2.3. Regional Workforce Density

Workforce density was calculated separately for radiologists and radiographers:

$$\mathrm{Density}_{ik} = \frac{N_{ik}}{P_i} \times 1,000,000 \tag{2}$$

where N_{ik} is the number of professionals from workforce group k in region i and P_i is the regional population. Density was expressed per million population. Primary internal reference densities were calculated from region-assigned counts and the total Census population: 149.2 radiologists and 626.7 radiographers per million. Sensitivity analysis used the source studies' published national densities of 147 radiologists and 640 radiographers per million.

2.4. Regional Variation and Inequality

The coefficient of variation was calculated separately for the 13 regional radiologist densities and 13 radiographer densities:

$$\mathrm{CV}_k = \frac{s_k}{\bar{x}_k} \times 100 \tag{3}$$

where s_k is the standard deviation and $\bar{x}_k$ is the mean regional density for workforce group k. The coefficient was expressed as a percentage.

The unweighted Gini coefficient was also calculated for each profession:

$$G_k = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_{ik} - x_{jk} \right|}{2n^2 \bar{x}_k} \tag{4}$$

where x_{ik} and x_{jk} are workforce densities in regions i and j, n is the number of regions, and $\bar{x}_k$ is the mean regional density. Higher values indicate greater inequality; 0 indicates equal density across regions. For 13 non-negative regional values, the uncorrected coefficient has a maximum of 12/13 rather than 1 [21]. Gini coefficients were calculated across the 13 region-level density values without population weighting.

2.5. Geographic Distribution

Spearman rank correlations described associations between regional headcounts and, separately, between their population-adjusted densities. Proportional differences between the geographic distributions were assessed using the dissimilarity index:

$$D = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{R_i}{\sum_{i=1}^{n} R_i} - \frac{T_i}{\sum_{i=1}^{n} T_i}\right| \quad (5)$$

where R_i and T_i are regional radiologist and radiographer counts. The index ranges from 0, indicating identical proportional distributions, to 1, indicating complete dissimilarity [22].

2.6. Descriptive Regional Classification

Regions were classified relative to the aggregate region-assigned densities of 149.2 radiologists and 626.7 radiographers per million. Four descriptive patterns were defined: high–high, high radiologist–low radiographer, low radiologist–high radiographer, and low–low. High indicated density at or above the corresponding reference and low indicated density below it. Sensitivity analysis repeated the classification using the published national references of 147 and 640 per million.

2.7. Statistical Analysis

Counts, percentages, densities, ratios, medians, interquartile ranges, ranges, fold differences, coefficients of variation, Gini coefficients, and the dissimilarity index were calculated. Partial Spearman correlation was computed as the Pearson correlation of residuals obtained after regressing each profession's headcount ranks on regional population ranks. Because the analysis described all 13 administrative regions, correlations were reported descriptively, without inferential *p*-values or sampling confidence intervals. Each correlation, coefficient of variation, Gini coefficient, and the dissimilarity index was recalculated after omitting one region at a time. The minimum and maximum describe sensitivity to individual regions, not sampling uncertainty. Published professional-rank summaries were used to compare radiologists with and without a known region. For radiographers, the mean age among records with a known region was approximated by weighting the published regional mean ages by their corresponding headcounts; this derived mean was compared with the published mean for records without regional assignment.

Two scenarios tested sensitivity to missing regional assignment. The unassigned counts were allocated either in proportion to each profession's observed geographic distribution or in proportion to each region's share of the 2022 Census population. Regional ratios were recalculated without rounding the allocated counts. An exploratory unweighted linear regression related radiographer density to radiologist density. Regional residuals were reported, and the model was refitted without Najran to examine its influence.

The analysis plan was not preregistered. The coefficients of variation, Gini coefficients, dissimilarity index, and density classifications were part of the original analysis. The partial correlation, leave-one-region-out calculations, missing-assignment scenarios, and density regression were added in response to peer review. Analyses were reproduced in R version 4.5.1. Densities, ratios, and categories are descriptive and do not establish staffing adequacy, shortage, surplus, or service capacity.

3. Results

3.1. National Workforce Composition and Geographic Completeness

The source studies reported 5150 radiologists and 22,626 radiographers nationally, equivalent to 4.39 radiographers per radiologist. Regional location was unavailable for 350 radiologists (6.8%) and 2461 radiographers (10.9%). Among 4800 radiologists and 20,165 radiographers assigned to the 13 regions, the aggregate ratio was 4.20. Aggregate region-assigned densities were 149.2 radiologists and 626.7 radiographers per million residents (Table 1). Consultants represented 36.1% (1735/4800) of radiologists with a known region and 18.9% (66/350) of those without one. Among radiographers, the estimated mean age obtained by weighting the published regional means by headcount was 35.3 years for records with a known region, compared with the reported mean of 25.5 years for records without one [12,13].

Table 1. Published national workforce counts and regional assignment by profession.

Measure	Radiologists	Radiographers	Notes
Total national workforce, n	5150	22,626	Overall ratio: 4.39
Region-assigned workforce, n	4800	20,165	Region-assigned ratio: 4.20
Location unavailable, n (%)	350 (6.8%)	2461 (10.9%)	Excluded from regional comparisons
Population denominator	32,175,224	32,175,224	Saudi Census 2022
Aggregate region-assigned density per million	149.2	626.7	Primary classification references

Note: The region-assigned counts exclude records without a known administrative region. The aggregate densities use the combined Saudi Census 2022 population of the 13 regions. Derived regional measures are reported separately in Table 2.

Table 2. Summary measures of workforce distribution and composition across Saudi Arabia's 13 administrative regions.

Measure	Estimate	Leave-One-Region-Out Range
Regional ratio: median (Q1–Q3)	4.38 (3.64–5.02)	—
Regional ratio: minimum–maximum	3.08–7.60 (2.46-fold)	—
Headcount Spearman ϱ	0.967	0.958–0.979
Density Spearman ϱ	0.313	0.189–0.483
Partial Spearman ϱ, population-adjusted	0.573	0.280–0.706
Radiologist density CV	15.4%	13.4–16.1%
Radiographer density CV	32.7%	24.6–34.3%
Radiologist density Gini	0.084	0.073–0.087
Radiographer density Gini	0.167	0.132–0.174
Dissimilarity index	0.075	0.064–0.096
Primary density patterns	2/2/3/6	—
Alternative density patterns	3/3/2/5	—

Note: CV, coefficient of variation; Q1 and Q3, first and third quartiles. The ranges show sensitivity to omitting one region at a time and are not confidence intervals. Pattern counts are ordered high–high, high–low, low–high, low–low (radiologist classification first).

3.2. Regional Variation and Geographic Distribution

Regional variation was greater for radiographer density than radiologist density (Table 2). The coefficients of variation were 32.7% and 15.4%, respectively, and the unweighted Gini coefficients were 0.167 and 0.084 (Figure 2). Spearman correlations were 0.967 for headcounts and 0.313 for densities. The partial headcount correlation after accounting for population was 0.573. The respective leave-one-region-out ranges were 0.958–0.979, 0.189–0.483, and 0.280–0.706. The dissimilarity index was 0.075.

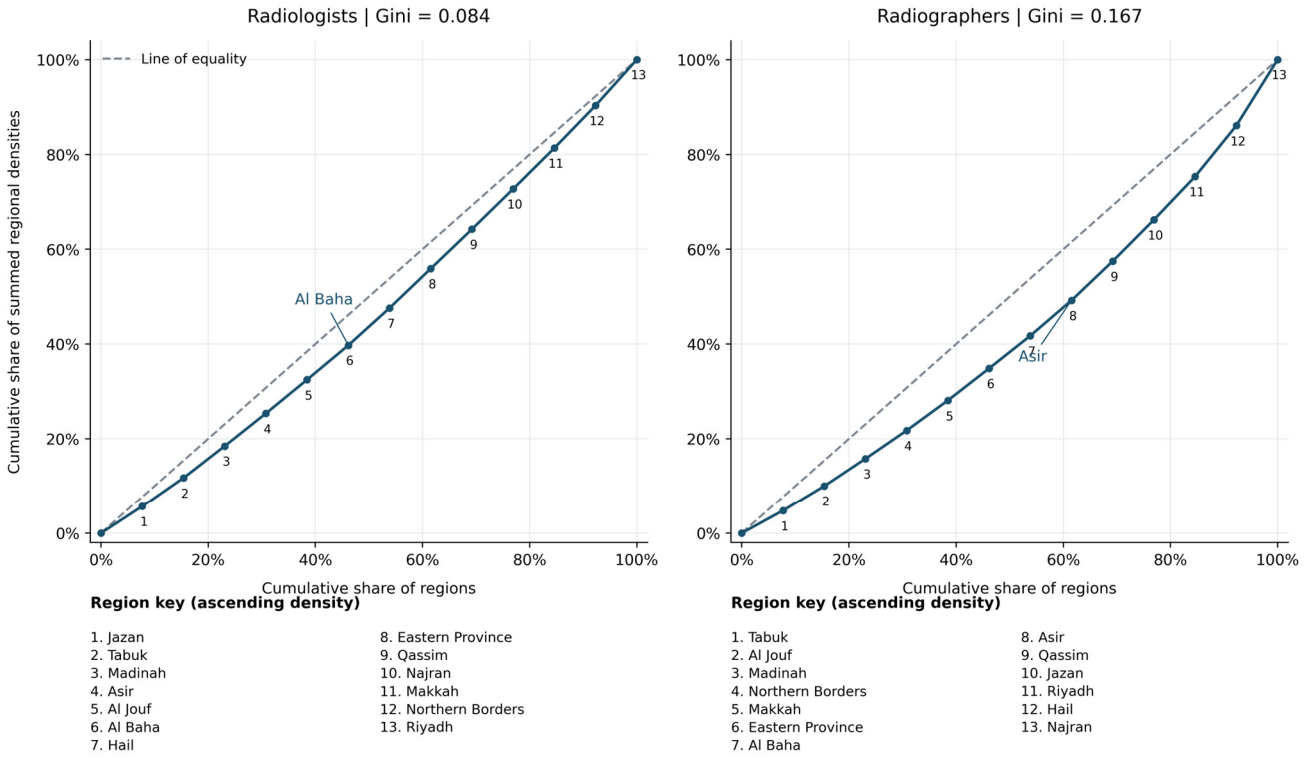

Figure 2. Regional inequality in radiologist and radiographer densities across Saudi Arabia. Lorenz curves show the cumulative share of summed regional densities against the cumulative share of regions. Regions were ranked separately for each profession by ascending density per million residents and weighted equally. The dashed diagonal represents equality. Numbered points correspond to the profession-specific region keys below the panels. Al Baha and Asir mark the cumulative ranks with the largest vertical gaps from equality for radiologists and radiographers, respectively; these ranks do not identify individual regions that contribute most to inequality.

The exploratory density regression accounted for 9.5% of the observed variation ($R^2 = 0.095$). Najran had the largest positive residual (+472.6 radiographers per million) and the Northern Borders the largest negative residual (−213.4 per million). Omitting Najran reduced the slope from 3.05 to 1.63. Residuals describe deviations from the fitted relationship, not staffing gaps.

3.3. Regional Radiographer-to-Radiologist Ratios

The median regional ratio was 4.38 radiographers per radiologist (interquartile range, 3.64–5.02). Regional ratios ranged from 3.08 in the Northern Borders to 7.60 in Najran, an approximately 2.46-fold difference (Figure 3B). Jazan (7.18) and Hail (6.33) had the next highest ratios. Profession-proportional reallocation of unassigned records increased each ratio by 4.58% and preserved all ranks by construction. Population-proportional reallocation narrowed the maximum-to-minimum contrast to 2.27-fold. The Northern Borders and Najran remained the lowest- and highest-ratio regions, respectively; only Makkah and Al Jouf exchanged ranks.

3.4. Descriptive Regional Density Patterns

Using the aggregate region-assigned references, Riyadh and Najran were high–high. Makkah and the Northern Borders were high radiologist–low radiographer, whereas Qassim, Hail, and Jazan were low radiologist–high radiographer. Al Baha, Al Jouf, Madinah, Tabuk, the Eastern Province, and Asir were low–low. With the published national references, Qassim changed to high–high and the Eastern Province changed to high radiologist–low

radiographer; the other 11 regions were unchanged. Their radiologist densities (148.9 and 148.7 per million, respectively) fell between the primary reference (149.2) and the alternative reference (147); neither changed its radiographer density classification (Figure 3A, Table 3).

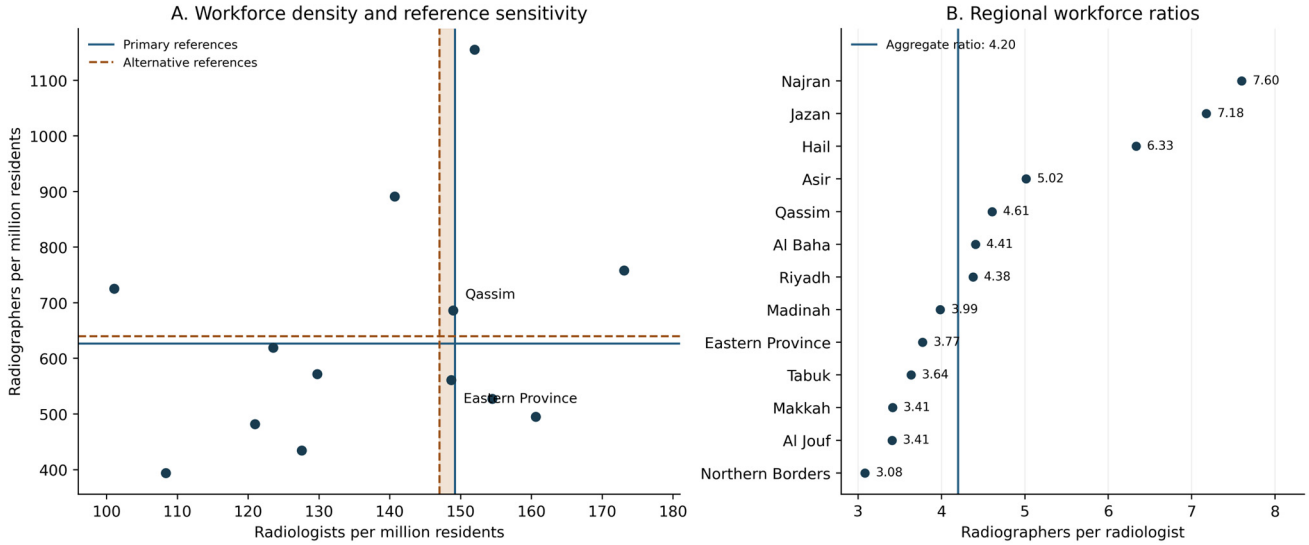

Figure 3. Regional workforce densities and ratios for Saudi Arabia's 13 administrative regions. (**A**) Radiologist and radiographer densities per million residents. Solid blue lines indicate aggregate region-assigned densities (149.2 and 626.7 per million, respectively); dashed orange lines indicate the alternative published references (147 and 640 per million). Qassim and Eastern Province are labelled because their radiologist densities fall between the two references and their classifications change accordingly. (**B**) Regional radiographer-to-radiologist ratios. The solid blue line indicates the aggregate ratio among records assigned to a region (4.20). Reference lines are descriptive and do not represent staffing adequacy thresholds.

Table 3. Regional population, workforce counts, densities, and radiographer-to-radiologist ratios.

Region	Population (2022 Census), n	Radiologists, n	Radiographers, n	Radiologists per Million	Radiographers per Million	Radiographers per Radiologist	Primary Density Pattern
Al Baha	339,174	44	194	129.7	572.0	4.41	Low–low
Al Jouf	595,822	76	259	127.6	434.7	3.41	Low–low
Northern Borders	373,577	60	185	160.6	495.2	3.08	High radiologist–low radiographer
Qassim	1,336,179	199	917	148.9	686.3	4.61	Low radiologist–high radiographer
Madinah	2,389,452	289	1152	120.9	482.1	3.99	Low–low
Tabuk	886,036	96	349	108.3	393.9	3.64	Low–low
Jazan	1,404,997	142	1019	101.1	725.3	7.18	Low radiologist–high radiographer
Najran	592,300	90	684	152.0	1154.8	7.60	High–high
Eastern Province	5,125,254	762	2876	148.7	561.1	3.77	Low–low
Makkah	7,769,994	1200	4097	154.4	527.3	3.41	High radiologist–low radiographer
Riyadh	8,591,748	1487	6514	173.1	758.2	4.38	High–high

Table 3. *Cont.*

Region	Population (2022 Census), n	Radiologists, n	Radiographers, n	Radiologists per Million	Radiographers per Million	Radiographers per Radiologist	Primary Density Pattern
Hail	746,406	105	665	140.7	890.9	6.33	Low radiologist–high radiographer
Asir	2,024,285	250	1254	123.5	619.5	5.02	Low–low
Total/pooled aggregate	32,175,224	4800	20,165	149.2	626.7	4.20	—

Note: Population counts are from the Saudi Census 2022. Densities use 2025 headcounts and the 2022 Census denominator. Aggregate densities use pooled counts divided by the combined regional population, equivalent to the population-weighted mean of regional densities. The aggregate ratio is the pooled radiographer count divided by the pooled radiologist count, not an arithmetic mean of regional ratios.

4. Discussion

Regional headcounts were more closely correlated than densities per million residents. Studying the two professions together across common administrative units showed that regions with similarly ranked workforce sizes did not necessarily have similarly ranked population-adjusted densities. Radiographer density also varied more between regions than radiologist density, a finding that persisted when each region was omitted in turn.

The regional ratio should be interpreted as a measure of professional composition rather than a staffing target. A high ratio can reflect relatively more radiographers, relatively fewer radiologists, or both. Al Baha illustrates why ratios and densities should be considered together as its ratio of 4.41 was close to the aggregate value of 4.20, but its radiologist and radiographer densities of 129.7 and 572.0 per million were both below the corresponding internal references. A ratio close to the aggregate value therefore does not establish workforce sufficiency. Service capacity also depends on examination volume and complexity, modality mix, operating hours, equipment, professional scope, and supporting personnel [2,14,15,23,24]. The rationale for examining composition is that image acquisition and clinical reporting are complementary stages of imaging delivery [5,7]. However, their staffing relationship depends on task allocation and service organisation; this study did not test whether a particular ratio predicts workload, waiting times, quality, or patient outcomes.

Both workforce densities were above the primary references in Najran. In Jazan and Hail, radiographer density was above its reference while radiologist density was below its reference. Modality mix, facility roles, remote reporting, and referral flows could help explain these patterns, but the available data cannot distinguish among them.

Headcounts do not capture differences in professional rank or subspecialty mix. In the source radiologist study, consultants accounted for 39.9% of radiologists in the Central geographic grouping and 26.4% in the Southern grouping [12]. These broader groupings are not the 13 administrative regions used here and cannot establish whether rank or subspecialty mix explains the ratios seen in any individual region.

The lower partial correlation indicates that regional population size accounts for some of the association between workforce headcounts. The dissimilarity index describes differences between the geographic shares of the two professions and cannot establish equitable access. Workforce density likewise describes where staff are recorded, without showing how often residents use services locally or outside their region. Regional disparities have also been reported for other Saudi healthcare resources, including hospital beds [25].

The density-pattern analysis further shows why regional assessment should not rely on a single reference. Qassim and the Eastern Province changed categories when the

published national values replaced the internally consistent region-assigned references. These threshold-sensitive changes reflect proximity to the reference lines and reinforce that the categories are screening descriptions rather than definitive assessments of adequacy or shortage. Decisions about redistribution, training, recruitment, and infrastructure should therefore use longitudinal measures rather than binary high–low labels.

Differences in occupational definitions, reporting periods, geographical units, and service organisation limit direct comparison of imaging workforce densities and ratios across countries. European workforce surveys provide context on radiologist and radiographer staffing, but do not establish a benchmark for a combined Saudi team [15,24]. United Arab Emirates (UAE) research on radiologists' acceptance of expanded radiographer roles illustrates how task allocation may differ across settings [26]. In Ghana, a registry study documented substantial geographic concentration of radiologists [27]. In Croatia, county differences persisted despite growth in radiologist numbers. The inclusion of CT and MRI inventories illustrates how the present paired workforce analysis could be extended to assess the distribution of equipment alongside staff [28].

4.1. Policy Implications and Future Directions

Contemporary workforce-planning frameworks recommend linking professional composition to service demand, models of care, population health needs, professional capabilities, and local context [9,10,29–31]. The policy value of regional ratios would therefore be strengthened by integrating them with imaging volumes, modality mix, case complexity, infrastructure, accessibility, scopes of practice, and full-time-equivalent workload. This approach is consistent with the Saudi HSTP and avoids assuming that one national ratio is optimal for every region.

A regional health authority could start with a specific service question. In Najran, modality-specific workload, reporting turnaround, and the share of remotely reported examinations could help determine whether local reporting capacity is constrained. In the Northern Borders, examination volumes, radiographer coverage by shift, and outbound referrals could help assess acquisition capacity. In Al Baha, where both densities were below their references, waiting times, travel distances, and out-of-region referrals could help assess access. In Jazan and Hail, reporting workload and coverage would be useful starting points.

Future surveillance should link radiologist and radiographer registry data within a unified, regularly updated framework and evaluate whether regional composition corresponds to measurable differences in demand, access, workload, and performance. Registry records should be linked with employer sector, FTE employment, subspecialty and modality competencies, equipment distribution, examination volumes, waiting times, vacancy rates, and referral patterns. Existing Ministry of Health reporting indicates that staffing and imaging-activity data are available, but they are not currently linked in a form that permits profession-specific regional capacity assessment [20].

If local assessment identifies a persistent service gap, options include recruitment and retention incentives, adjustments to the training pipeline, centralised reporting or teleradiology, and task sharing. Any change in scope of practice requires appropriate training, credentialing, and oversight. Implementation may be constrained by incomplete workload data, digital connectivity, and regulatory requirements. A study of radiography technologists in Kuwait identified working conditions, professional recognition, and career development as areas to assess when considering retention [32]. Oman's teleradiology guideline provides a regional example of licensing and quality assurance requirements, rather than evidence that teleradiology will improve access in the regions studied [33].

The World Health Organization's Workload Indicators of Staffing Need (WISN) method estimates staffing requirements using service volumes, available working time, activity standards, and allowances [34]. The European Union Radiation, Education, Staffing & Training (EU-REST) project proposed it for radiographer staffing [14]. Needs-based simulation offers a complementary approach for modelling how population needs, service delivery, and the distribution of tasks across professions affect projected requirements [29–31]. Both require local inputs that regional ratios cannot provide. Where access is constrained, observed imaging activity may understate unmet need and should be considered alongside population needs and access indicators.

4.2. Limitations

This ecological, cross-sectional analysis supports description but not causal inference. Registered headcounts do not measure FTE staffing, and the source studies did not provide comparable detail on part-time work. Workforce data were extracted 39 days apart in 2025, whereas population denominators came from the 2022 Census. Densities were not age-standardised. Comparable regional data on sector, nationality, sex, training or subspecialty mix, urbanisation, and facility composition were unavailable across both professions. Modality mix, equipment, workload, referrals, and teleradiology were also not measured. Acquisition and reporting may occur in different regions, and recorded employment location may not reflect the population served. The 39-day interval also permits workforce mobility or registry updates, which may have proportionally larger effects in regions with smaller headcounts. Common eligibility does not establish identical completeness or updating of employment records. If a region's 2025 population were 10% higher than its 2022 population, the same headcount would yield a density 9.1% lower; this is an illustrative denominator calculation, not an estimate of observed regional growth. Population changes do not affect headcount ratios, but differential regional growth could affect density comparisons and classifications.

Both source studies used the recorded employment region, but whether they assigned or updated locations consistently is unknown. Exclusion of records with missing regions lowered the aggregate ratio from 4.39 to 4.20. Differences in radiologist rank and radiographer age between records with and without regional assignment caution against assuming they followed the same geographic distribution. The allocation scenarios do not identify where those professionals worked or establish the direction or magnitude of bias in an individual region.

With only 13 regions, individual regions can influence the unweighted Gini coefficients, coefficients of variation, dissimilarity index, and correlations. The leave-one-region-out ranges describe this sensitivity and are not confidence intervals. Classification depends on the chosen reference, particularly when regional densities are close to a boundary.

5. Conclusions

Across Saudi Arabia's 13 administrative regions, radiologist and radiographer headcounts were more strongly correlated than their population-adjusted densities, and the radiographer-to-radiologist ratio varied between regions. Density classifications depended on the reference used. These measures provide a descriptive baseline for follow-up with workload, FTE staffing, and measures of access to imaging; they do not establish staffing adequacy. Without linked workload, infrastructure, and service-model data, the operational significance of the regional differences remains uncertain.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/healthcare14234025/s1, Dataset file: The aggregate regional dataset, R code, and statistical outputs generated and analyzed during this study.

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Institutional Review Board Statement: Not applicable. This secondary ecological analysis used only published, aggregate, region-level data and involved no access to individual-level or identifiable records.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data used in this study were derived from previously published workforce studies and the 2022 Saudi Census [12,13,19]. The aggregate regional dataset, R code, and statistical outputs generated and analyzed during this study are available as Supplementary Materials.

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Conflicts of Interest: The author declares no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CV	Coefficient of variation
EU	European Union
SCFHS	Saudi Commission for Health Specialties
WISN	Workload Indicators of Staffing Need

Appendix A

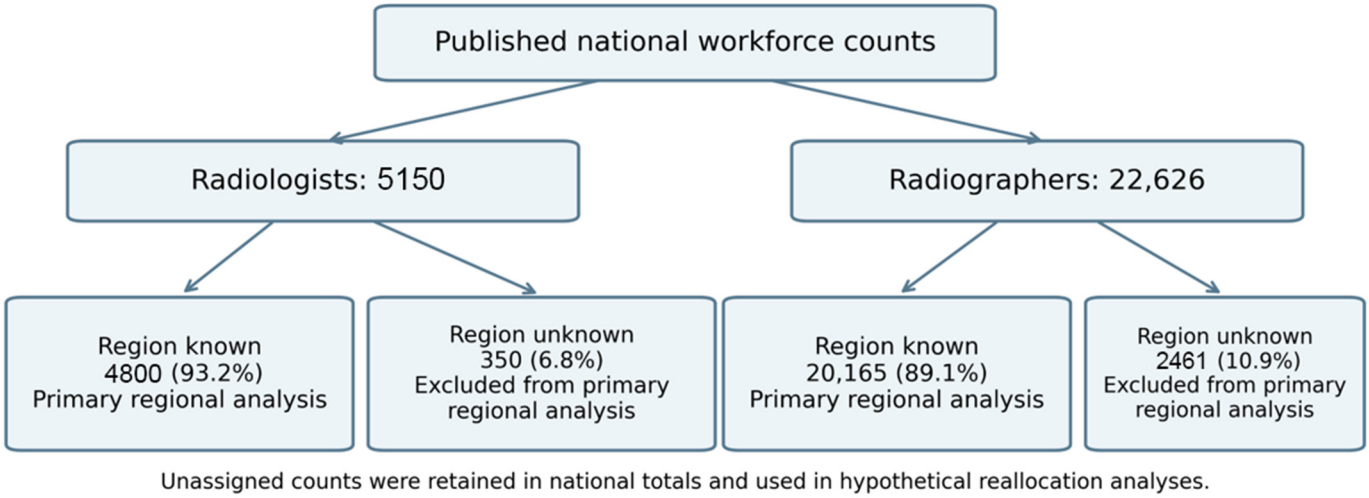

Figure A1. Reconciliation of published national workforce counts with counts used in the primary regional analysis. Counts without a known administrative region remained in the national totals and were used in the hypothetical reallocation analyses. Percentages use the national total for each profession. The unit of analysis was the administrative region (n = 13); individual-level records were not accessed.

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