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Beyond School Counts: National Spatial Inequalities in the Condition and Safety of Public-School Facilities in Saudi Arabia

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Abstract

Educational-infrastructure planning can overlook inequalities in the physical condition and safety of existing schools when provision is assessed mainly through school counts. This study examines the impact of national spatial inequalities in the condition and safety of public-school facilities in Saudi Arabi. For the study approach, there is a cross-sectional secondary analysis was conducted using 13,045 facility assessments covering all 13 regions and 149 governorates as the study population. The survey-derived building-quality score was analyzed alongside five original safety and condition domains, while multilevel and spatial analyses assessed geographic variation. The national mean building-quality score was 38.5 (SD 11.3), with regional means ranging from 32.5 to 39.8. Governorate means were spatially clustered, and rural facilities scored 2.54 points below urban facilities before adjustment; the difference attenuated to 0.23 points after building age and size were considered. The study highlighted a number of findings, the most important of which are the national mean survey-derived building-quality score was 38.5, with substantial variation among regions and governorates. As well, governorate mean condition scores showed significant positive spatial clustering. The study put forward several important recommendations, most notably the necessity of Establish a national, auditable school-asset register containing inspection dates, instrument versions, component ratings, evidence, remedial priorities, costs, work-order status, and reinspection outcomes. In addition, the study recommends prioritizing independent verification and rapid corrective action for facilities carrying severe life-safety survey ratings, particularly emergency exits and fire-pump systems.

Keywords: School counts; building condition assessment; National spatial inequalities; public schools; safety; Saudi Arabia.

* Introduction

Schools are simultaneously educational institutions, long-lived public assets, and daily environments in which children and staff spend substantial time. Planning a school system therefore requires more than locating facilities or counting them relative to population. A school may be geographically present while its physical condition, safety systems, or operational environment restricts the quality of service it can deliver. Conversely, a well-maintained building may operate in a territory where demand exceeds the available school stock. These are different planning problems and imply different interventions.

This distinction is consequential because the school-built environment has been associated with health, comfort, attendance, and educational performance, although the strength and causal interpretation of evidence vary by exposure, outcome, and study design. Reviews link ventilation, thermal conditions, lighting, acoustics, and maintenance to student experience and learning-related outcomes (Mendell & Heath, 2005; Haverinen-Shaughnessy et al., 2011; Barrett et al., 2019). Multilevel classroom research likewise demonstrates that design characteristics can explain meaningful variation in learning progress, but such findings are setting-specific and do not license the interpretation of a general building-condition score as a direct measure of learning (Barrett et al., 2015). Recent evidence from Maryland found that poorer facility conditions were associated with absenteeism and lower test performance, particularly in high-deprivation communities, while retaining the limitations of a cross-sectional design (Gong et al., 2026). Earlier mediation studies also suggest that attendance and school social climate may form pathways between building condition and academic outcomes (Durán-Narucki, 2008; Maxwell, 2016).

Building condition assessment offers a complementary asset-management perspective. Its purpose is to document current condition consistently, retain traceable evidence, and support maintenance, rehabilitation, and lifecycle decisions. Contemporary reviews show that visual inspection remains common, yet assessment models differ in domains, rating rules, aggregation, and treatment of uncertainty (Begić & Krstić, 2024). Defect-based and key-performance approaches can strengthen prioritisation, but only when scoring rules remain explicit and interpretable (Dejaco et al., 2017; Faqih & Zayed, 2021). A recent school-specific framework further illustrates how systematic condition grades and an asset database can turn dispersed observations into maintenance evidence (Begić Juričić & Krstić, 2025). These principles align with Saudi Arabia's national Condition Assessment Survey guidance, which emphasises asset identification, standardised checklists, traceable field evidence, condition categories, remedial priorities, and linked records (Government Expenditure & Projects Efficiency Authority, 2022).

The equity question is not whether all facilities have identical scores. It is whether systematic geographic or population-group differences reveal unequal exposure to deteriorated or safety-critical infrastructure, and whether those patterns are obscured by aggregate school counts. The OECD's well-being approach treats quality, safety, equity, inclusion, and accessibility as related but separable features of the built environment, and recommends component-level measurement rather than an undifferentiated total (OECD, 2023). A systematic review of the built environment and children's Quality of Life (QoL) found heterogeneous measures and mostly correlational evidence, with generally low certainty outside selected domains (Kodali et al., 2023). Accordingly, facility condition can be treated as a plausible QoL-related planning pathway, but it should not be reported as a direct QoL outcome without individual or longitudinal evidence.

Saudi studies have made important advances in mapping the distribution and accessibility of schools in individual cities and regions. Examples include GIS-supported planning in Jeddah, spatial equity analysis in Taif, and public elementary-school distribution in Najran (Al-Enazi et al., 2016; Ramadan et al., 2022; AlQuhtani, 2023). Saudi QoL research also places education within a wider, context-sensitive system of urban services, housing, safety, environmental conditions, and participation (Al-Qawasmi et al., 2021). However, the available literature is dominated by local distribution studies rather than national facility-condition evidence. The strongest recent Saudi school-safety study located for this research evaluated 17 girls' public schools in the Eastern Province and found variation across a detailed preparedness checklist (Al-Ansary et al., 2023). Its local depth is valuable, but it cannot establish the geographic distribution of condition or safety categories across the national school estate.

This study addresses that gap through a national analysis of administrative and site-survey records for government public-school facilities across all 13 regions and 149 governorates. It deliberately preserves three analytical boundaries. First, the survey-supplied building-quality percentage is analysed as received; no replacement weights or post hoc "quality" index are invented. Second, categorical safety and condition domains are reported separately so that a high overall score cannot compensate analytically for a critical component rating. Third, population per school building is treated as a governorate-level availability-pressure screen, not as a measure of accessibility, capacity, learning quality, or QoL.

*** Study Significance**

1- Its national and governorate-level coverage can support geographically targeted maintenance and rehabilitation decisions while highlighting the need for independent engineering verification.

2- It provides evidence for asset-management prioritisation by separating overall condition, component-level safety, and population pressure rather than collapsing them into a single index.

3- The study contributes a national facility-condition perspective that complements school-count and accessibility planning.

*** Study Objectives**

1- To derive planning implications for condition-based rehabilitation, life-safety verification, and capacity planning without making unsupported causal claims.

2- To assess the relationship between population pressure per school building and facility condition and identify dual-priority governorates.

3- To examine condition differences by urban–rural location, school stage, student sex, building sharing, building age, and facility size.

4- To quantify variation in facility condition across regions, governorates, and individual facilities and assess geographic clustering.

5- To describe the national and subnational distribution of the survey-derived building-quality score.

*** Study Hypotheses**

1- H4: Population pressure per school building is not a reliable proxy for facility condition, producing distinct planning-priority groups.

2- H3: Building age is negatively associated with the survey-derived building-quality score, whereas facility scale indicators such as classroom count show positive associations.

3- H2: Rural facilities have lower condition scores than urban facilities before adjustment, with part of the difference explained by building age and facility size.

4- H1: Building-condition scores differ geographically across Saudi regions and governorates and exhibit significant spatial clustering.

*** Study Questions and Problem**

1- Do population pressure and facility condition coincide geographically, and which governorates face a dual burden?

2- Do condition scores differ by urban–rural location, school stage, student sex, building sharing, age, and facility size?

3- How much variation occurs at regional, governorate, and facility levels, and are governorate mean scores spatially clustered?

4- How is the survey-derived building-quality score distributed nationally and across regions and governorates?

The central problem of the study is that counting and distributing schools does not necessarily reveal whether existing facilities are in adequate physical condition or provide safe environments.

*** Study Population**

The study population comprises the 13,045 eligible public-school facility assessments with a complete survey-derived building-quality score, representing facilities across all 13 Saudi regions and 149 governorates.

*** Study Limitations**

1- Subject-matter boundary: government public schools in the elementary, intermediate, and secondary stages, focusing on building condition, safety domains, geographic inequality, and population pressure per school building.
2- Spatial boundary: the Kingdom of Saudi Arabia, covering all 13 administrative regions and 149 governorates.
3- Temporal boundary: the analysis uses the available national administrative and site-survey extract; the source dataset does not contain inspection dates, so a precise fieldwork year cannot be established from the supplied material.

The researcher considers the distinction between school availability, facility condition, and life safety to be essential for equitable educational-infrastructure planning. The evidence indicates that a school-count approach alone can obscure facilities that require urgent rehabilitation or safety verification, while a condition-only approach can overlook areas where service capacity is under pressure.

*** Previous studies related to the research**

Al-Enazi, Mesbah, and Anwar (2016): examined school-distribution planning in Jeddah using GIS. The study is relevant because it demonstrates the value of spatial analysis for understanding the geographic distribution of school facilities. The present research extends this perspective from distribution toward national facility condition and safety.

Ramadan et al. (2022): modelled spatial equity priorities for elementary and middle schools in Taif using GIS techniques. The study is related to the present research through its emphasis on spatial equity and location-based planning, while the present study adds building-condition and safety evidence at the national scale.

Al-Ansary, El-Sharkawy, and Alsulaiman (2023): assessed safety preparedness in 17 public girls' schools in Saudi Arabia's Eastern Province using a detailed checklist. Its local evidence is particularly relevant to the present study's safety domains, while the current research broadens the geographic coverage to all 13 regions and 149 governorates.

AlQuhtani (2023): analysed the spatial distribution of public elementary schools in Najran, Saudi Arabia. The study supports the importance of spatially explicit school planning and provides a local Saudi comparison for the national geographic analysis undertaken here.

Gong et al. (2026): examined associations between physical school-facility conditions, absenteeism, and test performance in Maryland. Although conducted outside Saudi Arabia, it is relevant to the broader rationale for studying school physical environments. The present study differs by focusing on facility condition and safety patterns rather than estimating educational or health outcomes.

The researcher finds that the previous literature supports two complementary directions: spatial equity studies explain where school provision is located, while safety and facility-condition studies explain the quality of the physical asset. The present study is positioned at the intersection of these approaches by combining national spatial coverage with condition and safety evidence.

*** Materials and methods of the study**

*** Study design and reporting approach**

The study used a cross-sectional, observational design based on a national administrative registry linked to a comprehensive school-building site-survey extract assembled for the doctoral research. Reporting was structured with reference to the STROBE principles for observational studies (von Elm et al., 2007). The analytical protocol was designed to reproduce the supplied variables, distinguish facility- and governorate-level evidence, report missingness explicitly, and separate confirmatory descriptive comparisons from exploratory spatial screening.

*** Setting and scope**

The intended geography was the Kingdom of Saudi Arabia, comprising 13 administrative regions and 149 governorates. The sectoral boundary was fixed before analysis: government public schools in the elementary, intermediate, and secondary stages. Private and international schools, kindergartens, continuing education, higher education, vocational institutions, military-scope facilities, public–private partnership records outside the adopted scope, evacuated assets, and other facilities not coded within the governmental study boundary were excluded.

The source workbook contained 17,008 records. Its pre-existing Scope field classified 13,049 records as “In” and 3,959 as “Out.” All “In” records were coded as governmental. One “In” record lacked a target-stage classification, leaving 13,048 eligible facility assessments. Three eligible records lacked the building-quality score; the primary analysis therefore included 13,045 facilities (99.98% completeness for the primary outcome).

Table 1. Analytical sample construction

Selection step	Records retained	Excluded at step
Administrative school registry	17,008	—
Scope-coded public-school facilities retained	13,049	3,959
Elementary, intermediate, or secondary stage retained	13,048	1
Complete survey-derived building-quality score	13,045	3

Note. The primary sample retained 99.98% of eligible target-stage facilities with respect to the supplied building-quality score.

*** Data provenance and unit of analysis**

The extract combined administrative school attributes, geographic identifiers, facility coordinates, population and school-building totals repeated at governorate level, and site-survey measures. Tatweer Building Company and the AYEN Platform facilitated access to the national field data for the doctoral research. The analytical unit was the facility assessment record, identified by a unique unit code; inspection-report identifiers were unique when present. The variable recording the number of schools in the building was retained as an occupancy characteristic, allowing a facility to be classified as serving one school or a shared/co-located arrangement.

The extract did not contain inspection dates, inspector identifiers, the full survey instrument, or the formula and weights used to generate the supplied overall score. It is therefore described throughout as a "survey-derived building-quality score," not as an independently validated structural-condition or code-compliance index.

Outcomes and explanatory variables

*** Primary condition outcome**

The primary outcome was the source field translated as "building quality (%)", supplied on a 0–100 scale with higher values interpreted as better condition. We did not recompute this percentage, alter its weights, define unverified pass/fail thresholds, or combine it with population pressure. Analyses emphasised the full distribution, medians and interquartile ranges, geographic means with uncertainty, and variance components.

*** Safety and condition domains**

Five original Arabic categorical fields were translated without changing their order: excellent, very good, moderate, poor, very poor, dangerous, and unknown. The domains were emergency exits, fire-pump condition, perimeter fence, floor condition, and the general condition of external areas and access roads. "Dangerous" was analysed as the most severe survey-recorded category. Unknown values were removed only from the denominator of the relevant domain. These labels were not treated as legal determinations or independent engineering verification.

Evacuation status and sprinkler availability were excluded from national prevalence estimates because 95.9% and 79.7%, respectively, were missing in the eligible sample. Numeric electrical/mechanical, health-and-safety, and fire-extinguisher fields were not used as predictors of the overall score because they could be components of the supplied scoring system, which would risk mechanical circularity.

*** Equity and facility characteristics**

Pre-specified equity stratifiers were urban versus rural location, school stage, and the sex served by the school (boys versus girls). One mixed-sex record was omitted from sex-adjusted models. Building occupancy was coded as single-school or shared building using the supplied number of schools per building. The extended model added building age in decades, log base 2 of built area in square metres, and classroom count per 10 rooms. These were used to examine whether observed group differences reflected differences in the age or scale of the physical stock; coefficients remain associational.

Population pressure was the supplied governorate population divided by the number of school buildings. Because the same value was repeated on facility rows, it was collapsed to one value per governorate before any correlation or mismatch analysis. It was not treated as facility-level data.

*** Data-quality procedures**

The raw workbook was read without modification. Stage labels were normalised only to reconcile Arabic orthographic variants. Numeric values were coercively parsed, and impossible values were set to missing before the extended model: building age outside 0–100 years, classroom counts outside 1–100, floors outside 1–10, and built area outside 50–20,000 m². This affected 61 age, five classroom, 13 floor, and two area values. Floors were retained for audit but not included in the final models.

Seven governorate names appeared under more than one region, producing 157 region–governorate pairs rather than the intended 149 nested units. Eleven facility records carried a nonmodal region label within their named governorate. For the multilevel and regional analyses, those records were assigned to the modal region of the governorate; the raw region field was retained for sensitivity analysis. This correction changed no facility outcome and altered any regional mean by at most 0.039 score points.

Complete longitude–latitude pairs were available for 13,042 of the 13,045 primary records. Governorate analytical centroids were defined as the median longitude and latitude of facilities within each governorate. No school-level locations are reported in the manuscript.

Table 2. Characteristics of the primary facility sample

Characteristic	Category / statistic	Value
Coverage	Facilities	13,045
	Regions	13
	Governorates	149
School stage	Elementary	7,831 (60.0%)
	Intermediate	3,070 (23.5%)
	Secondary	2,144 (16.4%)
Residence	Urban	9,155 (70.2%)
	Rural	3,890 (29.8%)
Student sex	Boys	5,700 (43.7%)
	Girls	7,344 (56.3%)
	Mixed	1 (<0.1%)
Building occupancy	More than one school	7,548 (57.9%)
Building age	Median [IQR], years	36 [26–48] (n = 12,366)
Built area	Median [IQR], m^2	1,200 [900–1,650] (n = 13,040)
Classrooms	Median [IQR]	15 [11–20] (n = 12,985)
Playground	Present	6,051 (46.4%)
Potential playground	Sufficient space reported	4,991 (38.3%)
Building-quality score	Mean (SD)	38.54 (11.26)
	Median [IQR]	36.7 [30.5–43.5]

Note. Percentages use 13,045 as denominator unless a nonmissing n is shown. IQR = interquartile range; SD = standard deviation.

*** Statistical analysis**

Continuous variables were summarized using descriptive statistics, while categorical variables were reported as frequencies and percentages. Because facilities were clustered within governorates, uncertainty was estimated using a nonparametric governorate-cluster bootstrap with 2,000 replications and 95% percentile intervals (Efron & Tibshirani, 1993).

Three-level Gaussian random-intercept models were fitted using restricted maximum likelihood, with facilities nested within 149 governorates and governorates within 13 regions (Snijders & Bosker, 2012). The base model included location, school stage, student sex, and building sharing; the extended model additionally included building age, log2 built area, and classroom count. The models included 13,044 and 12,312 facilities, respectively.

Spatial autocorrelation was assessed using governorate mean scores and a six-nearest-neighbour graph, with Moran's I tested through 9,999 permutations and four- and eight-neighbour sensitivity analyses (Moran, 1950). Population pressure and condition were examined using Spearman's correlation and bootstrap estimation. Analyses were conducted in Python, with a fixed random seed and reproducible scripts.

*** Results of the study**

*** Sample and facility profile**

The primary sample contained 13,045 facility assessments across all 13 regions and 149 governorates. Elementary facilities represented 7,831 records (60.0%), intermediate facilities 3,070 (23.5%), and secondary facilities 2,144 (16.4%). Urban facilities accounted for 9,155 records (70.2%) and rural facilities for 3,890 (29.8%). Girls' schools accounted for 7,344 records (56.3%), boys' schools for 5,700 (43.7%), and one record served both. More than half of records (7,548; 57.9%) indicated that more than one school used the building.

Among plausible nonmissing values, median building age was 36 years (IQR 26–48), median built area was 1,200 m² (IQR 900–1,650), and median classroom count was 15 (IQR 11–20). A playground was recorded for 6,051 facilities (46.4%), while 4,991 (38.3%) had space reported as sufficient to create one.

3.2 National and multiscale distribution of building condition

The mean survey-derived building-quality score was 38.54 (SD 11.26); the median was 36.7 (IQR 30.5–43.5). The 5th and 95th percentiles were 26.1 and 57.4, respectively, and the observed range was 0–90.3. The distribution was right-skewed and heterogeneous rather than concentrated near a single national norm (Figure 1A). Because the survey rubric supplied no validated interpretive cut points, these values are reported comparatively rather than labelled "passing" or "failing."

Regional mean scores ranged from 32.46 in Northern Borders to 39.79 in Riyadh, a 7.34-point span (Figure 1B; Table 3). Hail (35.75), Al Jawf (35.93), and Tabuk (36.63) were also below the national facility-weighted mean, while Qassim (39.62), Eastern (39.62), and Riyadh (39.79) had the highest regional means. Several regions had wide governorate-cluster intervals, illustrating that a regional average may conceal internal heterogeneity. Governorate mean scores ranged from 30.44 to 53.11, with an IQR of 35.76–39.67.

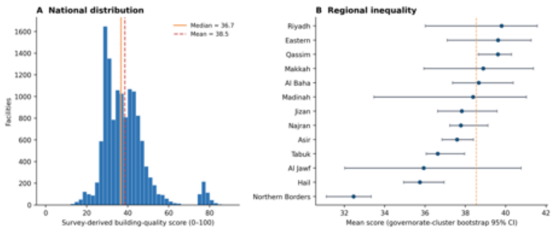

Figure 1. National distribution and regional inequality in the survey-derived building-quality score. Panel A shows the facility-level distribution. Panel B reports regional means with 95% governorate-cluster bootstrap CIs; the dashed vertical line is the national facility-weighted mean.

Table 3. Regional distribution of condition scores and selected safety categories

Region	Facilities	Govs.	Mean (95% CI)	Median [IQR]	Dangerous: exits / pumps
Riyadh	2,700	21	39.79 (36.01–41.56)	37.2 [30.4–44.9]	53.2% / 83.4%
Eastern	1,444	12	39.62 (37.10–41.26)	36.6 [31.7–43.2]	70.4% / 86.1%
Qassim	1,166	15	39.62 (38.64–40.29)	39.9 [34.0–44.2]	45.5% / 94.9%
Makkah	2,316	17	38.89 (35.94–41.38)	37.0 [30.3–43.5]	46.3% / 70.6%
Al Baha	384	10	38.66 (37.37–40.37)	38.2 [31.7–44.3]	41.9% / 82.3%
Madinah	825	9	38.38 (33.46–41.03)	36.6 [30.2–43.3]	49.3% / 86.5%
Jizan	813	17	37.82 (36.62–39.57)	37.1 [29.7–42.5]	49.7% / 69.0%
Najran	332	7	37.78 (37.22–39.12)	36.4 [30.9–43.0]	48.8% / 74.9%
Asir	1,534	17	37.59 (36.84–38.40)	36.2 [30.5–43.6]	46.0% / 93.1%
Tabuk	399	7	36.63 (36.06–37.96)	33.5 [30.2–43.2]	56.4% / 79.4%
Al Jawf	356	4	35.93 (32.02–40.76)	35.5 [30.0–40.2]	52.2% / 92.7%
Hail	546	9	35.75 (34.94–36.95)	35.5 [29.5–40.9]	48.9% / 96.1%
Northern Borders	230	4	32.46 (31.11–33.33)	30.8 [28.2–36.1]	67.0% / 94.8%

Note. Regional 95% CIs use 2,000 governorate-cluster bootstrap replications. Safety percentages exclude unknown categories. Govs. = governorates.

The null multilevel model estimated variance components of 1.54 at region level, 6.55 at governorate-within-region level, and 117.29 at facility level. The corresponding intraclass correlations were 1.2% for regions and 5.2% for governorates within regions; two facilities in the same governorate therefore shared an estimated 6.5% of total variance through the combined regional and governorate effects. Most variation remained between facilities, but the nonzero higher-level components show that geographic context was not negligible.

Governorate mean scores displayed positive spatial autocorrelation on the six-nearest-neighbour graph (Moran's I = 0.184; expected I = −0.0068; permutation p < 0.001). The conclusion was stable using four neighbours (I = 0.273; p < 0.001) and eight neighbours (I = 0.139; p < 0.001). Thus, governorates with similar mean condition tended to occur near one another more than expected under random spatial assignment, while the differing magnitudes appropriately caution against treating the statistic as graph-invariant.

*** Urban–rural and subgroup differences**

Urban facilities had a mean score of 39.30, compared with 36.76 in rural facilities. The facility-weighted rural–urban difference was −2.54 points (governorate-cluster bootstrap 95% CI −3.86 to −1.08). The direction varied geographically (Figure 2): rural means exceeded urban means in Al Baha, Jizan, and marginally Asir, whereas the largest rural disadvantages appeared in Madinah, Riyadh, Eastern, Makkah, and Qassim. The national rural gap is therefore not a universal region-level pattern.

Unadjusted stage means were nearly identical: 38.51 for elementary, 38.62 for intermediate, and 38.53 for secondary facilities.

Girls' schools averaged 39.58 versus 37.20 for boys' schools, a 2.38-point difference (95% CI 1.73 to 2.94). Facilities serving more than one school averaged 0.63 points below single-school facilities, but the cluster-bootstrap interval included zero (95% CI −1.18 to 0.02).

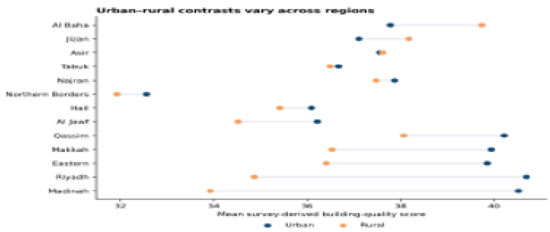

Figure 2. Urban–rural mean condition contrasts within regions. Dots are unadjusted facility-weighted means; connected values show that the direction and magnitude of the contrast vary geographically.

In the base multilevel model, rural location remained associated with a 0.99-point lower score (95% CI −1.53 to −0.45), and girls' schools with a 2.13-point higher score (95% CI 1.75 to 2.51). Stage and shared-building coefficients were small and imprecise. After building age, built area, and classroom count were added, the rural coefficient attenuated to −0.23 (95% CI −0.80 to 0.33), suggesting that differences in the composition of the physical stock accounted for much of the adjusted rural contrast. The girls' school coefficient also attenuated but remained positive (1.32; 95% CI 0.90 to 1.73).

Each additional decade of building age was associated with a 1.09-point lower condition score (95% CI −1.22 to −0.96). Ten additional classrooms were associated with a 1.31-point higher score (95% CI 0.95 to 1.68), while a doubling of built area had little independent association (−0.10; 95% CI −0.45 to 0.25). In the extended model, shared buildings averaged 0.55 points lower than single-school buildings (95% CI −0.97 to −0.14); intermediate and secondary facilities averaged 0.54 and 1.28 points below elementary facilities after covariate adjustment. These coefficients describe conditional associations and should not be interpreted as effects of adding classrooms, changing school stage, or assigning students by sex.

Table 4. Adjusted associations with the survey-derived building-quality score

Term	Base β (95% CI)	p	Extended β (95% CI)	p
Rural (vs urban)	-0.99 (-1.53 to -0.45)	<0.001	-0.23 (-0.80 to 0.33)	0.420
Intermediate (vs elementary)	-0.32 (-0.78 to 0.14)	0.173	-0.54 (-1.01 to -0.07)	0.025
Secondary (vs elementary)	-0.53 (-1.07 to 0.00)	0.052	-1.28 (-1.85 to -0.72)	<0.001
Girls (vs boys)	2.13 (1.75 to 2.51)	<0.001	1.32 (0.90 to 1.73)	<0.001
Shared building (vs single school)	-0.17 (-0.58 to 0.23)	0.393	-0.55 (-0.97 to -0.14)	0.010
Building age (per 10 years)	—	—	-1.09 (-1.22 to -0.96)	<0.001
Built area (per doubling)	—	—	-0.10 (-0.45 to 0.25)	0.579
Classrooms (per 10)	—	—	1.31 (0.95 to 1.68)	<0.001

Note. Three-level random-intercept models used restricted maximum likelihood. Base n = 13,044; extended n = 12,312. Reference categories were urban, elementary, boys, and single-school building. Coefficients are score-point differences. CI = confidence interval.

*** Survey-recorded safety and condition categories**

The categorical domains revealed information not conveyed by the overall percentage. Emergency exits were rated "dangerous" for 6,726 of 13,043 assessments with a known category (51.6%), and "very poor" for a further 42.8%. Fire pumps were rated "dangerous" for 10,891 of 13,040 known assessments (83.5%). Perimeter fences were most often rated "poor" (56.4%), with 17.2% "dangerous" and 15.5% "very poor." Floors were most often "poor" (55.2%), while 6.6% were "dangerous." External areas were also most frequently “poor” (89.0%), but 2.2% were “dangerous.”

Safety patterns varied by region rather than following the overall score ranking exactly (Figure 3). The proportion of emergency-exit assessments rated “dangerous” ranged from 42% in Al Baha to 70% in Eastern. Fire-pump “dangerous” ratings ranged from 69% in Jizan to 96% in Hail. Rural facilities had a lower prevalence of dangerous emergency-exit ratings than urban facilities (46.6% versus 53.7%) but higher prevalence for fire pumps (89.2% versus 81.1%) and perimeter fences (21.8% versus 15.3%). This mixed pattern reinforces the need for component-specific remediation rather than a single rural or regional label.

Table 5. Distribution of the original survey-recorded condition categories

Domain	Known n	Dangerous	Very poor	Poor	Moderate / very good / excellent
Emergency exits	13,043	6,726 (51.6%)	5,583 (42.8%)	98 (0.8%)	4.9%
Fire pumps	13,040	10,891 (83.5%)	970 (7.4%)	51 (0.4%)	8.7%
Perimeter fence	13,044	2,243 (17.2%)	2,028 (15.5%)	7,360 (56.4%)	10.8%
Floor condition	13,045	858 (6.6%)	2,404 (18.4%)	7,201 (55.2%)	19.8%
External areas	13,044	281 (2.2%)	565 (4.3%)	11,611 (89.0%)	4.5%

Note. Categories reproduce the source survey labels after direct translation. They are not independent engineering or code-compliance determinations. Unknown values are excluded from each domain denominator.

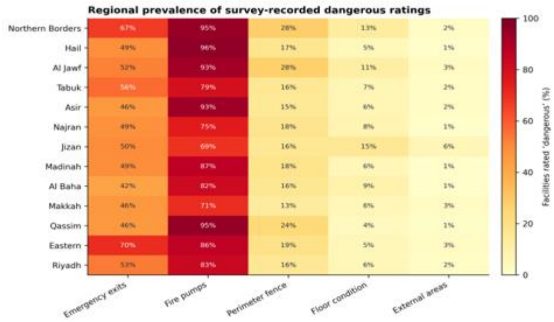

Figure 3. Regional prevalence of survey-recorded “dangerous” ratings by component. Percentages exclude missing and unknown categories. Survey labels are not independent code-compliance determinations.

*** Population pressure and condition mismatch**

At governorate level, population per school building ranged from 596 to 6,933, with a median of 1,118. The correlation between population pressure and mean facility condition was small and uncertain (Spearman’s $\rho = 0.072$; $p = 0.381$; bootstrap 95% CI −0.098 to 0.244). Governorates with similar levels of population pressure could therefore have materially different condition profiles, and vice versa.

Using the transparent median quadrant screen, 38 of 149 governorates combined above-median population pressure with below-median condition (Figure 4). These governorates contained 3,471 analysed facilities, or 26.6% of the primary sample. Thirty-six governorates had above-median pressure but higher condition; 36 had lower pressure and lower condition; and 39 had lower pressure and higher condition. The nearly even allocation across quadrants is consistent with the weak rank correlation and demonstrates why population pressure should not be used as a proxy for building condition.

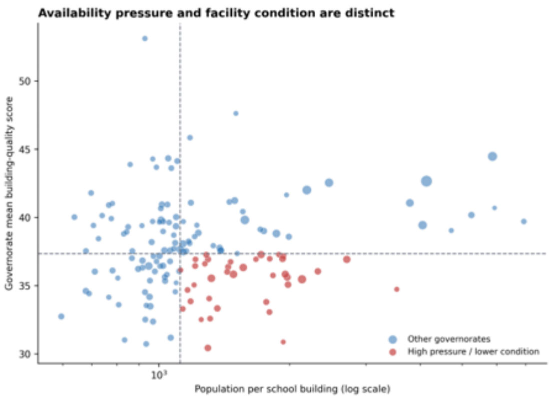

Figure 4. Governorate-level mismatch between population pressure and mean facility condition. Dashed lines show governorate medians; point size represents analysed facility count. Red points combine above-median population per school building with below-median mean condition. Axes remain separate and the quadrant is a screening rule, not a threshold standard.

*** Discussion of study results**

*** Principal findings**

This national analysis produces five main findings. First, the school estate exhibited substantial facility-level variation and a 7.3-point range between regional means, with even wider differences among governorates. Second, geographic context accounted for a modest but meaningful portion of variance, and governorate means were spatially clustered across alternative neighbour definitions. Third, rural facilities had a lower unadjusted mean, but the difference was not uniform across regions and largely attenuated after building age and facility size were considered. Fourth, life-safety-related survey categories were frequently severe, especially for emergency exits and fire pumps, and their geography did not simply reproduce the overall quality-score ranking. Fifth, population pressure per school building was largely independent of mean facility condition, producing a sizeable dual-priority group that would be missed by a count-only or condition-only planning system.

The findings do not imply that a national mean of 38.5 represents failure against a known standard. The supplied score rubric and interpretive thresholds were not available, so the defensible inference is comparative: regions, governorates, and facility groups occupy different positions on the same source scale. In contrast, the categorical findings can be described using their original labels, but "dangerous" still denotes the survey category rather than an independently verified legal or engineering determination. These distinctions are central to avoiding overclaiming.

*** From National Averages to a Multiscale Asset Problem**

The findings indicate that school-facility management requires a multiscale approach. Although most condition variation occurs locally, governorate-level results showed meaningful spatial clustering. National policy is therefore necessary to standardize assessment and minimum responses, while governorate and facility-level actions are needed to identify and address specific problems. Regional averages alone may overlook localized backlogs, whereas individual facility rankings may miss geographically concentrated needs.

Effective asset management should link each facility to its location, inspection evidence, condition ratings, remedial actions, and lifecycle decisions. Future data should also retain inspection dates, assessment versions, component weights, photographs, repair priorities, and closure status. Spatial clustering further supports longitudinal investigation of shared construction, environmental, procurement, and maintenance factors.

The researcher believes that the multiscale pattern supports a governance model in which national authorities establish common assessment and safety standards, while regional, governorate, and facility levels identify and address specific maintenance backlogs.

*** Interpreting the rural gap**

The raw rural deficit of 2.54 points is planning-relevant because nearly 30% of analysed facilities were rural. However, this difference should not be interpreted as evidence of a uniform rural disadvantage. Rural facilities exceeded urban means in several regions, and the adjusted difference decreased after accounting for building age and facility scale, suggesting that part of the gap reflects differences in the composition of the physical stock.

This attenuation does not make rural inequality unimportant. Building age and facility size reflect historical investment, settlement patterns, replacement cycles, and planning policies. Therefore, raw and adjusted estimates address different questions: the former describes observed condition differences, while the latter identifies residual differences after controlling for observable characteristics.

The positive association between classroom count and condition score, and the negative association with building age, may reflect renewal cycles, maintenance differences, or characteristics embedded in the scoring system. Because the data are cross-sectional and the scoring formula is unavailable, causal mechanisms cannot be established.

The researcher considers that the rural–urban gap should therefore be treated as a planning signal rather than a simple geographic disadvantage. Policy should prioritize renewal cycles, ageing facilities, and stock composition alongside geographic location, supported by longitudinal asset data for stronger future assessment.

*** Why school counts and condition must remain separate**

The weak governorate-level association between population pressure and condition is not a null result of little consequence. It is direct evidence that the two indicators answer different questions. Population per school building screens relative availability pressure. The condition score summarises the physical state recorded by the adopted survey. A high-pressure governorate may possess comparatively better buildings yet need additional capacity; a lower-pressure governorate may require rehabilitation rather than expansion. Combining the two into a weighted average would make these distinct intervention needs less visible.

The 38 dual-priority governorates illustrate the practical value of a two-axis screen. They contain more than one quarter of analysed facilities and face both above-median population pressure and below-median condition. Yet the median split remains only a first-stage flag. Population per building does not represent enrolment capacity, classroom utilisation, multiple shifts, travel time, cross-boundary attendance, or age-specific demand. Likewise, a mean condition score can conceal a small number of facilities with severe component ratings. Capital decisions require both axes plus local capacity and engineering evidence.

The researcher concludes that capacity pressure and physical condition represent different planning problems. Keeping them as separate axes makes it possible to distinguish expansion needs from rehabilitation needs and to identify governorates requiring both forms of intervention.

*** Relationship to Quality of Life**

Safe, functional, and inclusive schools are plausible contributors to health, learning opportunity, family confidence, and community well-being. The OECD framework supports treating built-environment quality as one component of a multidimensional well-being system (OECD, 2023). However, the systematic review by Kodali et al. (2023) cautions that built-environment–QoL evidence for children is heterogeneous and largely correlational. This study contains no student, parent, staff, health, attendance, achievement, or subjective-well-being outcome. It therefore does not estimate the effect of school condition on QoL.

The contribution is more specific: the paper supplies a national measurement layer needed before such pathways can be tested. Facility condition can be linked prospectively to attendance, health, achievement, satisfaction, maintenance expenditure, and neighbourhood indicators. Longitudinal changes following verified remediation would provide stronger causal evidence than a cross-sectional association between an infrastructure score and a broad city QoL index.

The researcher takes into school-facility condition a plausible infrastructure pathway to broader well-being, but the current dataset does not permit direct measurement of Quality-of-Life effects. Establishing that relationship requires longitudinal and outcome-linked evidence.

5. Planning and policy implications

The results support a dual-axis national triage system in which population pressure and facility condition remain visible and are supplemented by a non-compensatory life-safety override.

Table 6. Two-axis planning triage with a non-compensatory safety override

Safety override: Any severe life-safety category enters a verification and corrective-action pathway regardless of quadrant or overall score.

Population pressure	Lower condition	Higher condition
Higher pressure	Dual-action priority Verify safety; rehabilitate or replace; test capacity expansion and utilisation.	Capacity priority Protect current condition; assess enrolment, shifts, classrooms, and expansion options.

Population pressure	Lower condition	Higher condition
Lower pressure	Asset-renewal priority Verify safety; evaluate rehabilitation, replacement, adaptive reuse, or evidenced consolidation.	Preventive-maintenance / monitoring Maintain asset quality and evaluate whether capacity can be rebalanced without reducing access.

Note. "Higher" and "lower" in the empirical screen refer to governorate medians and are descriptive, not regulatory thresholds.

First, life-safety verification should precede routine condition ranking. Any facility with a severe emergency-exit, fire-pump, structural, or comparable critical rating should enter a verification queue independent of its overall percentage. The queue should record inspection date, responsible team, evidence, interim controls, final determination, and closure of the corrective action.

Second, asset renewal should be planned at facility and governorate scales. Facility-level models are needed for repair packages and lifecycle costing; governorate patterns are useful for bundling contracts, identifying shared environmental or procurement problems, and aligning maintenance capacity. Region-level dashboards are suitable for oversight but insufficient for project selection.

Third, capacity and condition programmes should be coordinated but not blended. The high-pressure/lower-condition quadrant requires joint investigation of rehabilitation or replacement and service expansion. High-pressure/higher-condition governorates require capacity and utilisation analysis while protecting current asset quality. Lower-pressure/lower-condition areas need decisions among rehabilitation, replacement, adaptive reuse, or carefully evidenced consolidation. Lower-pressure/higher-condition areas require monitoring, preventive maintenance, and examination of whether capacity can be rebalanced without undermining access.

Fourth, future data releases should implement an auditable school-asset register. Minimum fields should include a stable building identifier, the schools sharing it, coordinates, inspection date, instrument version, inspector or team, component-level ratings, evidence links, remedial priority, estimated cost, work-order status, reinspection date, and outcome. Population, enrolment, classrooms, shifts, and utilisation should be maintained as separate demand and capacity fields.

Finally, equity monitoring should report distributions and severe-component prevalence, not only averages. Urban–rural, girls'/boys', stage, and construction-cohort comparisons should be repeated after each inspection cycle. The objective is not identical scores everywhere, but transparent evidence that differences reflect legitimate functional needs rather than avoidable maintenance or investment inequities.

*** Key Results**

1- The national mean survey-derived building-quality score was 38.5, with substantial variation among regions and governorates.

2- Governorate mean condition scores showed significant positive spatial clustering.

3- Rural facilities had a lower unadjusted mean than urban facilities, but the difference largely attenuated after accounting for building age and facility size.

4- Severe survey-recorded ratings occurred frequently for emergency exits and fire pumps, highlighting the need for component-specific verification.

5- Population pressure per school building had a weak relationship with facility condition, and 38 governorates combined above-median pressure with below-median condition.

6- The findings support treating school availability, facility condition, and life safety as separate but coordinated planning dimensions.

*** Recommendations**

1- Establish a national, auditable school-asset register containing inspection dates, instrument versions, component ratings, evidence, remedial priorities, costs, work-order status, and reinspection outcomes.

2- Prioritise independent verification and rapid corrective action for facilities carrying severe life-safety survey ratings, particularly emergency exits and fire-pump systems.

3- Use separate capacity and condition axes in national planning, with a safety override that takes precedence over composite condition scores.

4- Direct rehabilitation and renewal programmes toward facility and governorate levels rather than relying only on regional averages.

5- Repeat urban–rural, girls'/boys', educational-stage, and construction-cohort comparisons after each inspection cycle.

6- Collect longitudinal information on maintenance, utilisation, enrolment, attendance, health, achievement, and satisfaction to test whether facility improvements are associated with broader educational and well-being outcomes.

7- Avoid treating population per school building as a direct measure of capacity, accessibility, or service quality without complementary enrolment, utilisation, travel-time, and engineering evidence.

The researcher theorizes that the most important practical implication to be the adoption of a two-axis planning framework—capacity pressure and facility condition—combined with a non-compensatory life-safety override. This framework is more transparent than relying on school counts or a single composite score and can support evidence-based prioritisation of rehabilitation, replacement, and capacity expansion.

*** Conclusion**

Saudi Arabia's public-school estate cannot be adequately understood through school counts alone. Based on 13,045 facility assessments, building-condition scores varied substantially within and between governorates, while governorate-level means showed clear spatial clustering. Survey-recorded life-safety categories also indicated serious component-specific concerns that require independent technical verification. Although rural facilities had lower unadjusted condition scores, much of this difference was associated with the age and scale of the existing physical stock. Importantly, population pressure per school building did not provide a reliable proxy for facility condition. The analysis identified 38 governorates combining relatively high population pressure with relatively low facility condition, while other governorates fell into three distinct intervention profiles.

These findings suggest that school planning should treat availability, physical condition, and life safety as interconnected but non-equivalent dimensions. A national planning framework should therefore maintain separate capacity and condition measures, apply a non-compensatory safety override, preserve traceable inspection evidence, and systematically evaluate outcomes following remediation. Such an approach would provide a stronger and more defensible basis for prioritizing maintenance, rehabilitation, expansion, and safety interventions across Saudi Arabia.

From the researcher's viewpoint, the study demonstrates that the adequacy of the national school system cannot be judged by the number of buildings alone. Integrating spatial condition evidence, component-level safety information, and population-pressure screening offers a more comprehensive basis for evidence-informed planning. However, because the study relies on cross-sectional facility data, its findings should be interpreted as associational rather than causal. Safety-related findings should also be independently verified before informing regulatory, engineering, or investment decisions.

*** References**

Al-Ansary, N. F., El-Sharkawy, M. F., & Alsulaiman, S. A. (2023). Safety preparedness in Arab public schools. Heliyon, 9(9), e19635. https://doi.org/10.1016/j.heliyon.2023.e19635

Al-Enazi, M., Mesbah, S., & Anwar, A. (2016). Schools' distribution planning using GIS in Jeddah City. International Journal of Computer Applications, 138(1), 33–36. https://doi.org/10.5120/ijca2016908693

Al-Qawasmi, J., Saeed, M., Asfour, O. S., & Aldosary, A. S. (2021). Assessing urban quality of life: Developing the criteria for Saudi cities. Frontiers in Built Environment, 7, 682391. https://doi.org/10.3389/fbuil.2021.682391

AlQuhtani, S. (2023). Spatial distribution of public elementary schools: A case study of Najran, Saudi Arabia. Journal of Asian Architecture and Building Engineering, 22(2), 705–725. https://doi.org/10.1080/13467581.2022.2049277

Barrett, P., Davies, F., Zhang, Y., & Barrett, L. (2015). The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis. Building and Environment, 89, 118–133. https://doi.org/10.1016/j.buildenv.2015.02.013

Barrett, P., Treves, A., Shmis, T., Ambasz, D., & Ustinova, M. (2019). The impact of school infrastructure on learning: A synthesis of the evidence. World Bank. https://doi.org/10.1596/978-1-4648-1378-8

Begić, H., & Krstić, H. (2024). Comprehensive review and comparative analysis of building condition assessment models. Results in Engineering, 22, 102176. https://doi.org/10.1016/j.rineng.2024.102176

Begić Juričić, H., & Krstić, H. (2025). Developing a framework for building condition assessment of schools in Osijek-Baranja County. Buildings, 15(9), 1511. https://doi.org/10.3390/buildings15091511

Dejaco, M. C., Cecconi, F. R., & Maltese, S. (2017). Key performance indicators for building condition assessment. Journal of Building Engineering, 9, 17–28. https://doi.org/10.1016/j.jobe.2016.11.004

Durán-Narucki, V. (2008). School building condition, school attendance, and academic achievement in New York City public schools: A mediation model. Journal of Environmental Psychology, 28(3), 278–286. https://doi.org/10.1016/j.jenvp.2008.02.008

Efron, B., & Tibshirani, R. J. (1993). An introduction to the bootstrap. Chapman & Hall/CRC.

Faqih, F., & Zayed, T. (2021). Defect-based building condition assessment. Building and Environment, 191, 107575. https://doi.org/10.1016/j.buildenv.2020.107575

Gong, C. H., Lofton, R., Fernandes, P., Johnson, O., & Sharfstein, J. M. (2026). Cracks in the foundation: The association of physical condition of school facilities with absenteeism and test scores in Maryland. Journal of School Health, 96(4), e70131. https://doi.org/10.1111/josh.70131

Government Expenditure & Projects Efficiency Authority. (2022). National manual of assets and facilities management (Vol. 3, Chap. 3): Condition assessment survey (CAS) (Document No. EOM-ZC0-PR-000009 Rev 001).

Haverinen-Shaughnessy, U., Moschandreas, D. J., & Shaughnessy, R. J. (2011). Association between substandard classroom ventilation rates and students' academic achievement. Indoor Air, 21(2), 121–131. https://doi.org/10.1111/j.1600-0668.2010.00686.x

Kodali, H. P., Hitch, L., Dunlap, A. F., Starvaggi, M., Wyka, K. E., & Huang, T. T. K. (2023). A systematic review on the relationship between the built environment and children's quality of life. BMC Public

Health, 23, 2472. https://doi.org/10.1186/s12889-023-17388-8
Maxwell, L. E. (2016). School building condition, social climate, student attendance and academic achievement: A mediation model. Journal of Environmental Psychology, 46, 206–216. https://doi.org/10.1016/j.jenvp.2016.04.009
Mendell, M. J., & Heath, G. A. (2005). Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature. Indoor Air, 15(1), 27–52. https://doi.org/10.1111/j.1600-0668.2004.00320.x
Moran, P. A. P. (1950). Notes on continuous stochastic phenomena. Biometrika, 37(1/2), 17–23. https://doi.org/10.1093/biomet/37.1-2.17
OECD. (2023). Built environment through a well-being lens. OECD Publishing. https://doi.org/10.1787/1b5bebf4-en
Ramadan, M. S., Khairy, N., Alogayell, H. M., Alkadi, I. I., Ismail, I. Y., & Ramadan, R. H. (2022). Spatial equity priority modeling of elementary and middle schools through GIS techniques, El-Taif City, Saudi Arabia. Sustainability, 14(19), 12057. https://doi.org/10.3390/su141912057
Snijders, T. A. B., & Bosker, R. J. (2012). Multilevel analysis: An introduction to basic and advanced multilevel modeling (2nd ed.). SAGE.
von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. PLoS Medicine, 4(10), e296. https://doi.org/10.1371/journal.pmed.0040296