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Assessing Walking and Cycling around Schools

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Abstract: To encourage students to walk and cycle to school and ensure their health and safety, it is essential to provide safe and operationally efficient infrastructure around schools. This study used an audit tool to assess the infrastructure and environment around schools in the city of Doha, Qatar, with a particular emphasis on active transport (walking and cycling). The aim was to identify strengths, weaknesses, and areas for improvement. Twenty-two schools with varied education levels were assessed. Among all assessed categories, active transport items scored the lowest, requiring the most improvements. A detailed analysis was conducted based on school type (elementary, primary, high, and mixed-schools) and revealed similar results except for elementary schools (scored acceptable for active transport). The study revealed that adding bike lanes, installing bicycle parking, and providing good separation of travel modes are the most needed improvements at school sites. In summary, improving active transport could significantly improve the overall quality of the infrastructure around schools in Qatar. Such improvements could greatly encourage more school children to walk and cycle to school instead of being primarily dropped-off and picked up by their parents' vehicles or school buses.

Keywords: built environment; active transport; traffic safety; active commuting; physical activity

1. Introduction

As indispensable institutions in any community, schools require well-planned and well-connected infrastructure. Selecting appropriate school sites and ensuring safe routes and efficient school designs within communities could improve children's school performance and instill in them lifelong healthy habits, such as active transportation [1]. Active transportation around schools is defined as school children's ability to choose to walk or cycle as part of their travel to school. Macro-environmental factors (design, density, and diversity of land use), micro-environmental features (pedestrian-friendly designs), and parents' and children's perceptions of walking or cycling to school are some of the main barriers to modes of active transportation to and from school [2,3].

Moreover, traffic exposure also influences parents' and children's perceptions of active transportation. Studies have shown that high street connectivity combined with low traffic exposure could increase neighborhood walkability and encourage more children to walk or cycle regularly to school [4,5]. While well-connected road networks can offer direct access to schools, they also increase the probability of traffic accidents and injury to those who are directly associated with schools, especially school children [6]. Unsurprisingly, high traffic exposure and low street connectivity have the opposite effect [6,7]. It is, therefore, essential to provide environmentally safe and operationally efficient infrastructure around schools to ensure children's safety while walking or cycling to school.

To that end, it is necessary to constantly evaluate the infrastructure around schools to identify problems and provide solutions. The main objective of this study was to assess the walkability, safety, and efficiency of schools in Qatar, a high-income developing country in the Arabian Gulf region. More

specifically, the study aimed to identify strengths and weaknesses and provide recommendations for overall and specific improvements for different types of schools (elementary, middle, high, and mixed-schools), to find ways of getting children more physically active and increasing active school transportation. A comprehensive assessment of schools in Qatar or the Arabian Gulf region was not found in the literature; therefore, the evaluation of different types of schools in Qatar was found to be both essential and timely.

2. Literature Review

2.1. Walking and Cycling around Schools in Qatar

People in high-income developing countries such as Qatar walk and cycle less compared to developed countries due to several reasons including weather conditions [8–10], inadequate active transportation infrastructure [11–14], and traffic safety concerns [15–17]. For these reasons, school students are more dependent on their parents, private vehicles driven by chauffeurs, and school buses. A study surveying five schools in Qatar found that approximately 1% of children walked or cycled to school [18]. Fifty-eight percent were driven to school by a parent or driver, while 38% traveled by school bus. The high percentage of students transported by private vehicles is surprising. Despite its limited sample size, this study provides insight into school transportation mode preferences in Qatar. Parents' concerns regarding the lack of proper infrastructure, young children's lack of danger perception, girls walking alone or mixing with boys, and temperatures frequently exceeding 35 °C could be reasons that active transportation is a largely unattractive mode choice for traveling to and from school [18]. In Qatar, various types of schools can be identified according to education level (elementary, middle, high school, or mixed). Therefore, it is necessary to evaluate them from various perspectives to identify prevalent weaknesses specific to certain school types. Identifying and improving the infrastructure around schools can play a major role in promoting walking and cycling.

2.2. Strategies to Improve Infrastructure around Schools

There are several infrastructure-related strategies that could be implemented to increase active transportation among school students. A program in Colorado (safe routes to school) involving the improvement of several infrastructure urban-design elements was implemented to increase walking and biking to school. After the implementation of the program in an elementary school, 45% more students living within 2 miles of the school, walked or biked daily instead of using a car [19,20]. Additionally, street-scale urban design strategies focusing on improving or introducing street lighting, street crossings, traffic calming devices, streetscape, and sidewalk continuity has proven to encourage physical activity within a few blocks [21]. Likewise, in an initiative in the City of Toronto, the reconfiguration of 2 of the 4 motor travel lanes into 40 km long stretch of bicycle lanes resulted in a 23% increase in bicycle trips [22]. Similarly, other successful policies include modifying roadway design standards, increasing costs of parking, and making public transportation more accessible for bicycle users [23].

In short, to encourage physical activity within a few kilometers range, infrastructure improvement such as developing or improving sidewalks, bicycle lanes, street connectivity, and mixed land-use promoting the use of active transport to reach destinations are needed. Therefore, there is a need for proper assessment tools to evaluate the infrastructure around schools from various perspectives to identify prevalent weaknesses specific to specific school types.

2.3. School Audit Tools

Several audit tools for assessing schools have been developed over the years focusing on walkability [2,6,24,25], active transport [26–28], walkability and active school transport [7], or walkability and safety [25,29]. Zhu, et al. [29] used a 14-item audit tool, divided into six categories, namely maintenance, visual quality, physical amenities, safety, and others, to assess street-level

walkability [29]. Tarun et al., on the other hand, used the 39-item tool, developed [27] and validated in the UK [28], to assess the outdoor school environment and physical activity. The tool was categorized into six categories: access, surroundings, school grounds, aesthetics, usage, and general environment.

In contrast, the three-tier 22-item school audit tool developed by Lee et al., comprising of a street, school-site, and map-based audit tools offered a more comprehensive tool. The tool was based on the spatial Behavioral Model of Environment (BME) used by Moudon et al. [30] and Lee et al. [31] that links physical activity with different factors from the built environment [30,31]. The tool, however, did not include different important transport features related to the school environment, such as the road network and parking area. Consequently, the most recent 30-item tool developed by [32] is a simple, comprehensive, and straight-forward school audit tool that covers different audit items commonly used or recommended in the literature [32].

In developing countries, there is a need for a simple, adaptable, and comprehensive school audit tool. Since the SAT (school audit tool) was recently developed and validated in Qatar [32], the tool was selected for this study. This tool can be used for assessing safety (road network and school site characteristics) and efficiency (parking/loading facilities) of schools besides assessment of walkability (active transport elements). These items could be assessed together or separately as required. In this study, all items in the assessment tools were used in the analysis.

2.4. Objectives

The main objective of this study was to utilize an audit tool to assess walking and cycling infrastructure and environment around schools in the city of Doha, Qatar. More specifically, the study aimed to identify strengths and weaknesses then provide recommendations for overall and specific improvements, as well as improvements based on school type (elementary, middle, high, and mixed-schools). As part of the assessment, various aspects of the school sites (infrastructure and environment) that can affect the safety, health, and behavior of students were evaluated.

3. Methodology

3.1. School Audit Tool (SAT)

The 30-item audit tool, SAT, used in this study was recently developed by Shaaban et al [32] as an effective tool to assess the infrastructure around schools (see Table 1). In this tool, the items were sorted into four groups, namely school site, road network, parking-loading, and active transport. Each assessment group consisted of items that helped evaluate the major elements under that category most comprehensively. Moreover, a 4-point Likert-type scale was adopted in this tool to rate each item ordinally as 1 to 4 (undesirable, poor, acceptable, and good), making it possible to assess each item with ease, consistency, and detail across schools. A detailed description of the four ordinal scores for all items under the four assessment categories can be found in the SAT form [32].

Table 1. List of the 30-item in SAT.

School Audit Tool (SAT) 30-item	School Site 7-item	S1	Proximity to high-speed roads
		S2	Presence of major roads
		S3	Land-use in the surrounding area
		S4	Fence around school
		S5	Location of entrance
		S6	Multiple access points to school
		S7	Congestion problems
	Road Network 7-item	R8	Speed limit signs
		R9	School zone signing and pavement markings
		R10	Speed reduction methods
		R11	Road classification of the adjacent street
		R12	Adequate sight distance
		R13	Public bus accessibility
		R14	Amenities for physically challenged students
	Parking/Loading 9-item	P15	Adequate pick-up/drop-off zones for school buses
		P16	Adequate queuing area
		P17	Parking for service and emergency vehicles
		P18	Staff parking
		P19	Visitor parking
		P20	Safety of parents
		P21	Parking for high school students
		P22	Traffic organization duty
		P23	Parking problems
	Active Transport 7-item	A24	Walking and biking conditions
		A25	Availability of crosswalks
		A26	Availability of sidewalks
		A27	Availability of bike storage
		A28	Availability of bike lanes
		A29	Separation of travel modes
		A30	Pedestrian problems

3.2. Data Collection

Two auditors independently collected the ratings for 22 schools within Doha, Qatar, with varying education levels (see Figure 1 for the locations of the sample schools). The randomly selected school samples (n = 22) comprised of a diverse mix of elementary, middle, and high schools (see Table 2 for a summary of the schools). Ten of the 22 schools were mixed-level schools, while the rest were single-level schools. A mixed-level school is a school that included two or more different levels in the same school: elementary/middle, middle/high, or elementary/middle/high. In Qatar, students in elementary school are aged at least between 4–11 years old, 12–14 years old in middle school, and 15–17 years old in high school [33]. For the mixed-level schools, seven schools provided all levels of education, two schools provided elementary/middle education, and one school provided middle/high education. For the single level schools, four schools provided elementary level education, six schools provided middle-level education, and two schools provided high-level education.

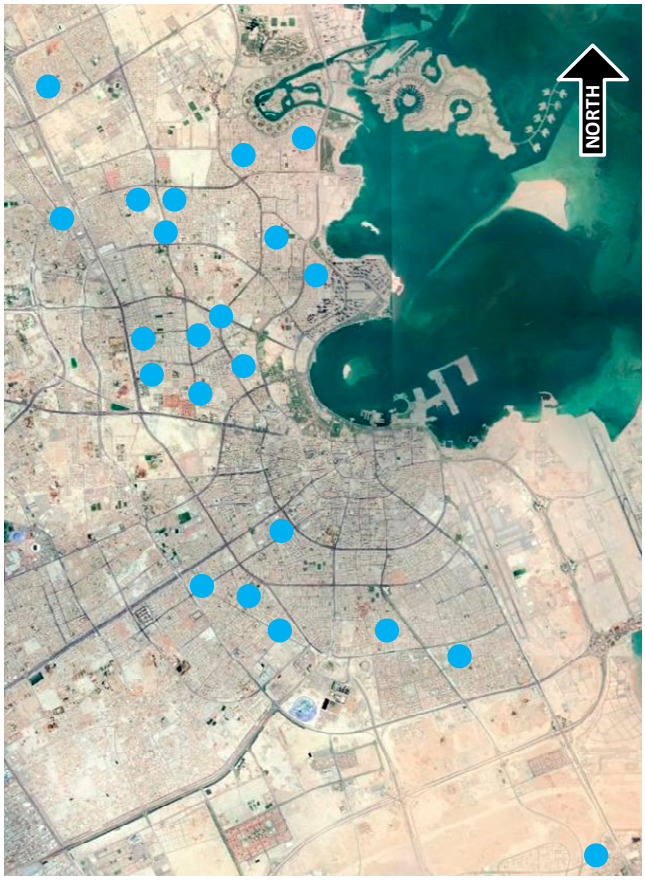

Figure 1. Location of randomly selected schools. (Source: Google Maps).

Table 2. Summary of the sample schools (n = 22).

School Name	Level
Al Bayan Education Complex for Girls	Elementary
Khawla Bint Al Azwar Independent Primary School for Girls	Elementary
Newton International School	Elementary
Doha English Speaking School	Elementary
Omar Bin Al Khattab Preparatory School for Boys	Middle
Hafsa Independent Preparatory School for Girls	Middle
Al Razi Preparatory Independent School for Boys	Middle
Al Wajba Preparatory Girls School	Middle
Amna Bint Wahab Preparatory School for Girls	Middle
Spectra Global School	Middle
Musab Bin Omair Secondary School	High
Umm Hakeem Independent School	High
Doha College	Elementary/Middle
Lycée Voltaire	Elementary/Middle
Al Andalus Preparatory & Secondary School for Boys	Middle/High
Jawan Bin Jassim Model Independent School for Boys	Elementary/Middle/High
Middle East International School	Elementary/Middle/High
Cambridge International School	Elementary/Middle/High
Doha Modern Indian School	Elementary/Middle/High
American Academy School	Elementary/Middle/High
English Modern School	Elementary/Middle/High
Lebanese School	Elementary/Middle/High

4. Analysis

Validation of the Audit Tool

It was necessary to validate the audit tool before analyzing the results. Since the application of the 4-point Likert-type tool was largely observation and perception-based, intraclass correlation coefficients (ICCs) measure was used to check the inter-rater and test-retest reliability and robustness of the tool. This method has been used in previous studies as a method for validating school audit tools [24,29]. Accordingly, the tool was applied to the selected schools, and the item-by-item and categorical ICCs were measured. ICCs measures, ranging between 0 and 1, offer an overview of the degree of disagreement between independent ratings of the same schools done by two raters (inter-rater) and 2 independent ratings done by the same rater (test-retest) [24,29,34]. For instance, the absolute ICCs values 0 and 1 indicate *random and perfect* agreement respectively; values above 0.75 indicate *good to excellent agreement*; values below 0.60 indicate *poor to fair* agreement; values between 0.60 and 0.75 indicate *moderate* agreement [24,35]. Separate validation was conducted for each type of school (single versus mixed). The statistical analysis was performed using the SPSS software.

For single-level schools, the reliability statistical analysis showed good to excellent results for both tests (see Tables 3 and 4). Most of the 30 item-by-item ICCs in inter-rater and test-retest tests received a score of 0.75 or more. Ratings of three items (public bus accessibility, parking for high school students, and availability of bike lanes) in the inter-rater test and seven items (proximity to high-speed roadway, land-use in surrounding area, speed reduction methods, road classification of adjacent street, amenities for physically challenged students, adequate bicycle storage, and availability of bike lanes) in the test-retest test were in complete match (ICC = 1).

Table 3. Results of categorical item-by-item inter-rater reliability tests.

Item	Single-Level Schools				Mixed-Level Schools			
	ICC	95% CI		*p*-Value	ICC	95% CI		*p*-Value
		Lower Limit	Upper Limit			Lower Limit	Upper Limit	
School Site								
S1	0.916	0.708	0.976	<0.0001	0.900	0.597	0.975	0.001
S2	0.896	0.637	0.970	<0.0001	0.853	0.407	0.963	0.004
S3	0.959	0.857	0.988	<0.0001	0.926	0.701	0.982	<0.0001
S4	0.880	0.583	0.965	0.001	1.000	-	-	-
S5	0.801	0.310	0.943	0.006	0.810	0.236	0.953	0.011
S6	0.762	0.173	0.931	0.013	0.882	0.523	0.971	0.002
S7	0.596	−0.404	0.884	0.074	0.677	−0.299	0.920	0.054
Road Network								
R8	0.983	0.941	0.995	<0.0001	0.987	0.947	0.997	<0.0001
R9	0.978	0.924	0.994	<0.0001	1.000	-	-	-
R10	0.733	0.072	0.923	0.019	0.949	0.796	0.987	<0.0001
R11	0.950	0.828	0.986	<0.0001	0.891	0.562	0.973	0.001
R12	0.828	0.401	0.950	0.004	0.390	−1.455	0.849	0.236
R13	1.000	-	-	-	1.000	-	-	-
R14	0.932	0.764	0.980	<0.0001	0.810	0.233	0.953	0.011
Parking Loading								
P15	0.767	0.190	0.933	0.012	0.710	−0.167	0.928	0.571
P16	0.827	0.397	0.950	0.004	0.591	−0.648	0.898	0.1
P17	0.877	0.573	0.965	0.001	0.837	0.345	0.960	0.006
P18	0.917	0.711	0.976	<0.0001	0.868	0.470	0.967	0.003
P19	0.934	0.771	0.981	<0.0001	0.801	0.201	0.951	0.012
P20	0.977	0.922	0.994	<0.0001	0.924	0.692	0.981	<0.0001
P21	1.000	-	-	-	0.690	−0.249	0.923	0.048
P22	0.878	0.576	0.965	0.001	0.921	0.682	0.980	<0.0001
P23	0.894	0.631	0.969	<0.0001	0.864	0.454	0.966	0.003
Active Transport								
A24	0.704	−0.027	0.915	0.027	0.913	0.650	0.978	0.001
A25	0.943	0.804	0.984	<0.0001	0.846	0.381	0.962	0.005
A26	0.923	0.733	0.978	<0.0001	0.904	0.612	0.976	0.001
A27	0.646	−0.228	0.898	0.049	1.000	-	-	-
A28	1.000	-	-	-	1.000	-	-	-
A29	0.786	0.256	0.938	0.008	0.769	0.071	0.943	0.02
A30	0.970	0.897	0.992	<0.0001	0.704	−0.191	0.927	0.042

Table 4. Results of categorical item-by-item test-retest reliability tests.

Item	Single-Level Schools				Mixed-Level Schools			
	ICC	95% CI		*p*-Value	ICC	95% CI		*p*-Value
		Lower Limit	Upper Limit			Lower Limit	Upper Limit	
School Site								
S1	1.000	-	-	-	0.900	0.597	0.975	0.001
S2	0.960	0.861	0.988	<0.0001	0.871	0.482	0.968	0.003
S3	1.000	-	-	-	1.000	-	-	-
S4	0.733	0.072	0.923	0.019	1.000	-	-	-
S5	0.908	0.682	0.974	<0.0001	0.684	−0.274	0.921	0.05
S6	0.938	0.784	0.982	<0.0001	0.897	0.587	0.975	0.001
S7	0.939	0.787	0.982	<0.0001	0.898	0.591	0.975	0.001
Road Network								
R8	0.983	0.941	0.995	<0.0001	0.978	0.910	0.994	<0.0001
R9	0.958	0.853	0.988	<0.0001	0.989	0.957	0.997	<0.0001
R10	1.000	-	-	-	1.000	-	-	-
R11	1.000	-	-	-	1.000	-	-	-
R12	0.522	−0.661	0.862	0.118	0.533	−0.879	0.884	0.136
R13	0.784	0.251	0.938	0.009	1.000	-	-	-
R14	1.000	-	-	-	0.889	0.553	0.972	0.002
Parking/Loading								
P15	0.914	0.702	0.975	<0.0001	0.851	0.400	0.963	0.005
P16	0.905	0.671	0.973	<0.0001	0.821	0.281	0.956	0.009
P17	0.821	0.377	0.948	0.004	0.957	0.827	0.989	<0.0001
P18	0.910	0.686	0.974	<0.0001	0.968	0.871	0.992	<0.0001
P19	0.957	0.852	0.988	<0.0001	0.968	0.870	0.992	<0.0001
P20	0.933	0.767	0.981	<0.0001	0.955	0.819	0.989	<0.0001
P21	0.930	0.758	0.980	<0.0001	1.000	-	-	-
P22	0.962	0.868	0.989	<0.0001	0.978	0.910	0.994	<0.0001
P23	0.877	0.573	0.965	0.001	0.887	0.547	0.972	0.002
Active Transport								
A24	0.935	0.776	0.981	<0.0001	0.889	0.553	0.972	0.002
A25	0.955	0.844	0.987	<0.0001	1.000	-	-	-
A26	0.966	0.883	0.990	<0.0001	0.972	0.887	0.993	<0.0001
A27	1.000	-	-	-	1.000	-	-	-
A28	1.000	-	-	-	1.000	-	-	-
A29	0.928	0.748	0.979	<0.0001	0.926	0.701	0.982	<0.0001
A30	0.964	0.876	0.990	<0.0001	0.785	0.133	0.947	0.016

For mixed-level schools, the reliability statistical analysis also showed good to excellent results for both tests (see Tables 3 and 4). Most of the 30 item-by-item ICCs in inter-rater and test-retest tests received a score of 0.75 or more. Ratings of five items (fence around school, school zone signing and pavement markings, public bus accessibility, adequate bicycle storage, and availability of bike lanes) in the inter-rater test and nine items (land-use in the surrounding area, fence around school, speed reduction methods, road classification of the adjacent street, public bus accessibility, parking for high school students, connected crosswalks, availability of bicycle storage, and availability of bike lanes) in the test-retest test were in a complete match (ICC = 1).

5. Qualitative Assessment of Schools

5.1. Scores and Assessment of Schools

The results of the qualitative assessment of each school and assessment category, along with the overall assessment were summarized in Table 5. In general, *good* (above 75%) scores mostly appeared for school site and road network categories. However, most *poor* scores (between 25% and 49%) were visible for active transport and some for parking/loading. Besides, none of the schools' ratings were found to be *undesirable* (below 24%). In short, active transport items needed the most attention for schools in Qatar.

Table 5. Overall scores of the schools in Qatar based on education level.

Level *	School Site		Road Network		Parking/Loading		Active Transport		Overall Assessment	
	%	Quality	%	Quality	%	Quality	%	Quality	%	Quality
1	82	Good	80	Good	77	Good	58	Acceptable	74	Acceptable
2	79	Good	68	Acceptable	60	Acceptable	43	Poor	63	Acceptable
3	64	Acceptable	59	Acceptable	55	Acceptable	34	Poor	53	Acceptable
1, 2	67	Acceptable	64	Acceptable	61	Acceptable	60	Acceptable	63	Acceptable
2, 3	69	Acceptable	55	Acceptable	42	Poor	32	Poor	49	Poor
1, 2, 3	76	Good	65	Acceptable	59	Acceptable	47	Poor	62	Acceptable
All Schools	75	Good	67	Acceptable	62	Acceptable	47	Poor	63	Acceptable

Note: 0–24% = Undesirable, 25–49% = Poor, 50–74% = Acceptable, and 75–100% = Good. * 1 = Elementary, 2 = Middle, 3 = High.

Furthermore, schools in Qatar differ based on the different education levels they offer due to the limitation of resources, the number of expected students, objectives, and so on. As students in elementary, middle, and high schools have different needs and requirements due to varying age ranges, their assessment results were also expected to differ. Table 6 shows the scores based on the education level. Elementary schools scored the highest overall score followed by middle, elementary/middle, and elementary/middle/high schools. High schools scored lower than elementary and middle schools. Again, the active transport category scored the highest number of *poor* assessments across education levels except for elementary and elementary/middle schools. Overall, the school site category scored the best (75%) across all school types followed by road network (67%), parking/loading (62%), and active transport (47%) categories. As such, active transport items received the lowest score and require the most attention and pertinent improvements.

5.2. Assessment Distribution of Schools

The previous section summarized the percent scores the different types of schools received across the four categories. In this section, the percent distributions of the schools across various assessments are illustrated in Figure 2. The figure shows the comparison of percent school distributions across education levels. The assessment distribution figure provides a better comparison of the schools in Doha across the categories since the number of schools for each school type was not the same.

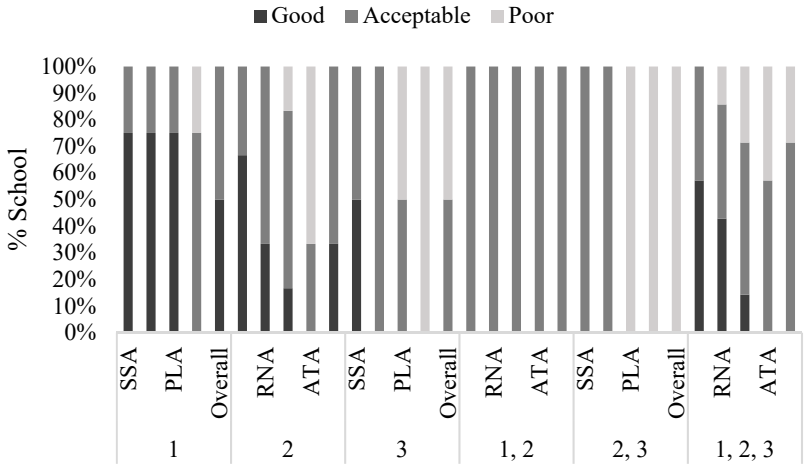

Figure 2. Comparison of percent school distribution between education levels. Education Level (1 = Elementary, 2 = Middle, 3 = High). Assessment Category (SSA = School site, RNA = Road network, PLA = Parking/Loading, ATA = Active Transport).

Table 6. Mean percent scores of the audit items in the SAT for the sample schools in Doha, Qatar.

Item	Description	All (%)	1 (%)	2 (%)	3 (%)	1, 2 (%)	2, 3 (%)	1, 2, 3 (%)
A28	Bike lane	25	25	25	25	25	25	25
A27	Adequate bicycle storage	27	25	25	33	25	25	29
R13	Public bus accessibility	31	38	25	42	25	25	32
P17	Parking for service & emergency vehicles	40	63	28	25	25	25	48
R14	Amenities for physically challenged students	45	44	64	54	25	25	35
A29	Separation of travel modes	45	46	50	25	33	50	49
S7	Congestion problems	53	63	51	42	54	33	54
P16	Adequate queuing area	54	52	60	54	50	33	54
P20	Safety of parents	55	88	46	50	58	25	50
P23	Parking problems	56	71	58	33	79	33	49
A24	Walking and biking conditions	56	71	50	42	71	50	54
A26	Availability of crosswalk	57	73	44	54	83	25	56
A30	Pedestrian problems	60	73	58	25	88	25	61
S2	Presence of major road	60	67	75	50	38	67	52
A25	Connected crosswalks	63	92	51	33	96	25	60
R8	Speed limit signs	63	98	38	58	88	25	64
P19	Visitor parking	64	83	67	58	54	42	58
P22	Traffic organization duty	64	79	58	63	58	25	69
S5	Location of entrance	64	75	68	54	42	42	68
R9	School sign & pavement marking	67	96	64	42	63	25	67
P15	Adequate parking & drop off space	76	88	82	58	79	75	68
S6	Multiple access to school	79	79	78	67	100	58	80
P18	Staff parking	83	90	82	96	83	75	79
R11	Road classification of adjacent street	87	96	96	63	63	100	86
S3	Land-use in surrounding area	88	100	90	75	75	100	85
R12	Adequate sight distance	89	92	92	83	88	83	88
S1	Proximity to high-speed roadway	91	94	100	79	63	100	92
R10	Speed reduction methods	91	96	99	71	100	100	85
S4	Fence around school	94	94	90	83	100	83	99

0–24% = Undesirable, 25–49% = Poor, 50–74% = Acceptable, and 75–100% = Good; 1 = Elementary, 2 = Middle, and 3 = High.

Overall, elementary schools were equally divided into 75% *good* and 25% *acceptable* scores for all categories except for active transport. For active transport, the scores were the lowest among the four categories and divided between 75% *acceptable* and 25% *poor*. This pattern was found to be closely repeated by middle schools. The majority of middle schools were found to score good for the school site, road network, and parking/loading. However, the results of active transport were worse than the other three categories with 33% *acceptable* and 67% *poor*. In the case of high schools, for school site, 50% of the schools scored *good* and 50% scored *acceptable*. In addition, 50% of high schools scored *acceptable* for parking/loading and 50% scored *poor*. However, all of the high schools scored *poor* for active transport.

For mixed schools, all elementary-middle schools scored *acceptable* across all domains. In addition, the middle-high school scored *acceptable* for school site and road network items and *poor* for parking/load and active transport items leading to an overall score of *poor*. Lastly, the mixed schools comprising of all education levels scored *good* for school site (57%) followed by road network (43%) and parking/loading (14%). These schools scored the least for active transport with 57% *acceptable* score and 43% *poor* score. To sum up, for mixed schools, active transport scored the lowest and in need of most improvements.

5.3. Scores of Audit Items

The school assessment results discussed in the previous sections were based on the mean scores of the audit items in the school audit (excluding the item related to parking for high school students) and

rated by the auditors for each of the sampled schools. The overall mean percent scores of the 29 audit items are illustrated in Figure 3 in ascending order. Likewise, the overall and the mean percent scores of the audit items for each school type based on education level are summarized in Table 6. The audit items in this table are also sorted based on ascending overall mean percent scores. The priority of the items requiring the most attention, as obtained from Figure 3 and Table 6, is indicative of how active transport items have received the least attention compared to the other elements of the school sites.

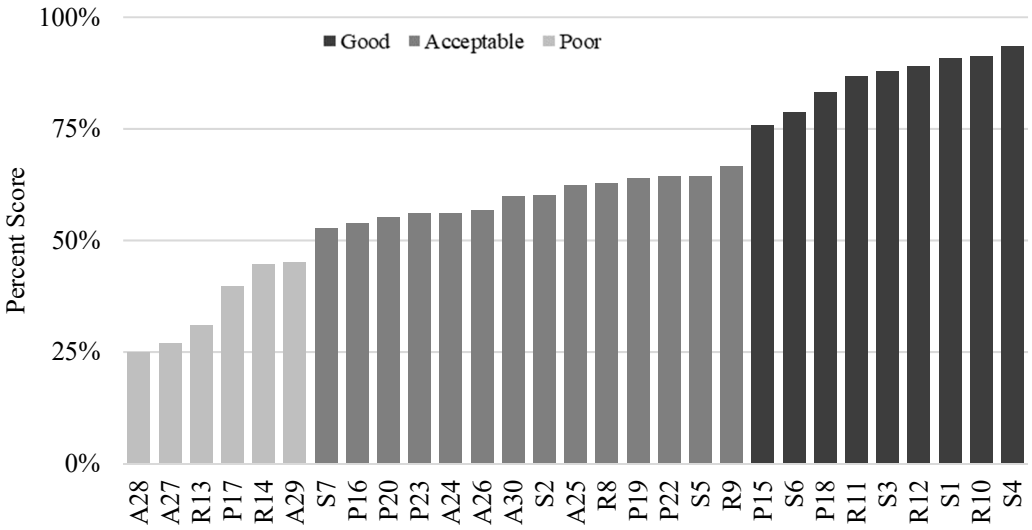

Figure 3. Mean percent score distribution of the audit items.

Out of six items that scored poor, three items were related to active transport (availability bike lane (25%), adequate bicycle parking (27%), and separation of travel modes (45%)). Additional poor items included two road network items (public bus accessibility (31%) and amenities for physically challenged students (45%)), and one parking/loading item (parking for service and emergency vehicles (40%)). *All remaining active transport items* received *acceptable* scores with 63% for connected crosswalks, 60% for pedestrian problems, 57% for availability of crosswalk, and 56% for walking and biking conditions. In general, no active transport items received *good* score. Furthermore, the mean percent scores of the active transport items under each school type were mostly similar to the overall percent scores of the active transport items.

6. Discussion

Infrastructure around schools is one of the important factors in increasing children's likelihood of walking or cycling to school. The purpose of this study was to assess the infrastructure and environment around schools in the city of Doha, Qatar with a special emphasis on active transport (walking and cycling). The primary objective was to identify strengths and weaknesses and provide recommendations for overall and specific improvements. A comprehensive audit tool was used to achieve this objective. The tool has well-defined scales to convert qualitative evaluation of existing school sites into a quantitative assessment. It includes a 30-item checklist categorized into four domains: school site assessment, road network assessment, parking/loading assessment, and active transport assessment. Th used tool is more comprehensive than the few school audit tools available in the literature [24,26]. The tool was validated with inter-rater and test-retest reliability tests. The overall results of the reliability tests indicated an overall good to excellent level of reproducibility. However, like previous studies, the overall reliabilities of the test-retest tests were higher than the results of the inter-rater tests [36–38].

In general, the overall assessment of the schools revealed acceptable scores. The school site category received the best scores. The road network and parking/loading categories received acceptable

scores. The results indicated that most of the active transport items scored poor, requiring the most improvements. Thus, significantly increasing the quality of these items could significantly elevate the overall quality of the infrastructure around schools in Qatar. A detailed analysis was conducted based on school type (elementary, middle, high, and mixed-schools). Elementary schools scored acceptable for active transport items. However, middle, high, and most of the mixed schools showed poor scores for these items. This was somewhat an indicator that public authorities need to consider improving active transport items at most of the schools. Such improvements could encourage more children to walk or cycle to school instead of being primarily dropped-off and picked up by their parents' vehicles or school buses. The analysis also revealed that adding bike lanes, ensuring adequate bicycle parking, and providing good separation of travel modes are the most needed improvements at school sites. Furthermore, additional items such as proper signs and pavement markings, safe crossings, well-connected sidewalks around school sites need to be provided or improved so that students are encouraged to walk or cycle to school and their parents are less concerned about their safety.

It is important to note that this study only assessed one aspect related to improving active transportation. Future studies are needed to explore other barriers that school children and parents experience. Although it was important to identify such weakness, improving the infrastructure may not necessarily increase active transportation since other factors including personal and social factors can also affect children's decision to walk and cycle to school [39]. Some of these factors include the education level of parents, car ownership, availability of school buses, personal barriers, positive attitude of children/parents, support of peers, and walking regularly.

In summary, there has been a general decline in the percentage of children who walked or biked to school [40]. Along with this decline, more children have become obese [41,42]. As a result of childhood obesity, the risks of developing serious short-term disease and chronic health issues as a child and then as an adult increase [43–52]. There is evidence that early interventions by schools, public agencies, and private organizations could help reverse the obesity epidemic by providing an environment that teaches and encourages young children to adopt a healthy and life-long active lifestyle [53,54]. Studies show that children who walk or cycle to school have been associated with increased levels of physical activity and better health [55–57]. Furthermore, physical education and activity combined with good nutrition and programs have been linked with positive academic performance in children [54]. Therefore, improvements in personal, social, and infrastructure factors may encourage more students to walk or bike to schools and improve problems related to childhood obesity and physical activity.

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