International Journal of Advanced Research in Engineering and Technology (IJARET)
Volume 11, Issue 4, April 2020, pp. 526-541, Article ID: IJARET_11_04_051
Available online at http://iaeme.com/Home/issue/IJARET?Volume=11&Issue=4
Journal Impact Factor (2020): 10.9475 (Calculated by GISI) www.jifactor.com
ISSN Print: 0976-6480 and ISSN Online: 0976-6499
DOI: 10.34218/IJARET.11.4.2020.051

QUALITY OF SOCIAL HOUSING IN METROPOLITAN LIMA

Julio Cesar Sanchez Barrera
Department of Architecture and Urbanism, Universidad Privada del Norte, Lima, Peru.

Arturo Valdivia Loro
Department of Architecture and Urbanism, Universidad Privada del Norte, Lima, Peru.

ABSTRACT

This article studies the quality and the satisfaction variables of the current situation as the housing in Metropolitan Lima, the Peruvian city with the highest population number, the largest number of homes from self-construction and, the lack of land to build new houses. Two instruments were designed to measure each one of the variables, and research was required to have a quantitative, transversal, and non-experimental approach. This study verified the direct relationship that exists between the variables and had determined the current state of each one. Besides, they will rank the dimensions of satisfaction for housing quality.

Key words: Housing quality, Index, Satisfaction, Instrument, Regression, Correlation.

Cite this Article: Julio Cesar Sanchez Barrera and Arturo Valdivia Loro, Quality of Social Housing in Metropolitan Lima, *International Journal of Advanced Research in Engineering and Technology,* 11(4), 2020, pp. 526-541.
http://iaeme.com/Home/issue/IJARET?Volume=11&Issue=4

1. INTRODUCTION

Housing is an important place for human beings because it means being the first place to understand the world (Zubiri, 1998; D'agiout, 2006). Its impetus lies in three dimensions: functional, because it shelters and protects them from inclement weather and other factors (UN-HABITAT, 2010); the emotional, because it represents the home or family (Sánchez Estévez, 2013) and the symbolic, because it allows satisfying the need for self-realization (Rodríguez and Sugranyes, 2004). That is, the right to decent housing implies satisfaction at all levels ranging from physiological to self-realization as a symbol of the goal of life (Maslow, 1991). In this way, the house allows the quality of life of its users through its quality.

However, quality has traditionally been interpreted as the product or service that meets objective specifications, which are logically measurable (Pérez, 2010). This can be interpreted and measured in another way, involving the client and estimating their level of satisfaction (Juran and Gryna, 2005). Therefore, the quality of the home does not consist only in evaluating the product based on its material presentation, considering, for example, its good image, resistance, that it does not have imperfections or scratches in the finish (deterioration), that it has the basic water, sewage and electricity services (Arévalo-Tomé, 1999; Cattaneo et al., 2009; Reátegui Vela, 2015) or that functionally respond to the planned activities, all of which are quantitative characteristics; but it is also conditioned to an emotional quality: that which implies and values the condition of home to the detriment of housing per se (Gifford, 2007).

A home must allow to satisfy the internal-subjective demands of the user related to their tastes and preferences, measured and interpreted through satisfaction scales, so that the quality home can meet not only all the requirements of a regulation and its utilitarian end, but also, being a means for the user to achieve satisfaction.

Cities will continue to grow (Soto-Cortés, 2015) towards the formation of megacities (Graizbord, 2007), either due to the influence of the social in the peripheries or due to capitalist pressure, in any case, with the sacrifice of the urban. On the one hand, the precariousness of housing concerns the urban sustainability and quality of life of people, especially those who live in vulnerable buildings due to empirical self-construction, and on the other hand, generating phenomena in the city, such as urban ghettos (security fantasies that expire outside the walls), with increasingly smaller houses and with more inefficient energy consumption with respect to electricity consumption (Hancevic and Navajas, 2015), segregating or gentrifying human groups and, therefore, segregating the city , either due to the fragmentation caused by mega-blocks of condominiums or by locations of economic and social discrimination (Macip, 2008).

SENCICO (2013), for example, ensures that 60% of homes in Peru are the product of self-construction. In Metropolitan Lima this figure rises to more than 50%. Likewise, of the total homes, 60% are vulnerable to earthquakes (El Comercio, 2014). To this last problem are added others:

There is less and less land in the city to cannibalize (Davis, 1994), because of the capitalist real estate sector (Schteingart, 1979).

When land is obtained, the phenomenon of gentrification appears (Soja, 2008), perhaps due to an oligopolistic market (Sánchez Arrastio, 2011), separating those economic groups towards the peripheries (Sabatini et al., 2017) and indirectly promoting the "autonomous" growth (Schteingart, 1979).

Due to the scarcity of land, both for the capitalist real estate sector and for autonomous growth, each time the housing problem approaches phenomena such as coffin homes and cage home (Dwan et al., 2013), with precarious conditions (Santana Rivas, 2013), or in the best case towards a cubicle home (Dwan et al., 2013).

In order not to continue with the detriment of the quality of life of users (Sánchez Barrera, 2015), the present article proposes as an objective to know the satisfaction of the user's quality of housing through satisfaction levels, and its relationship with an index of quality of housing measured objectively. With this, consider an empirical model that estimates the housing quality index in Metropolitan Lima, which, as a proposal, also serves as a control tool for housing design in the short term.

The research also seeks to identify and rank the degree of relationship between each of the dimensions of satisfaction with quality of housing and the index of quality of housing in Metropolitan Lima. Being such dimensions: Housing-City Relation, Housing-Environment Relation and, Housing Characteristics (Living space).

2. METHOD

The research design for the present work is non-experimental. Likewise, it is descriptive as it indicates the characteristics and properties of the Housing Quality Index (HQI) and the Housing

Quality Satisfaction (HQS). It is also a cross-sectional investigation because the data collection process was carried out in the same period, in 2017. Finally, it is a correlational investigation because the HQI and HQS were related, through statistical models that allowed finding some relationship between them.

Two instruments were designed for data collection. The first is a survey that measures Household Quality Satisfaction (HQS) of heads of household, made up of 67 questions with a Likert-type response scale (1-5); the second, an instrument for consulting the expert (verification sheet), made up of 13 indicators with a scoring scale (0-5), which measures the Housing Quality Index (HQI) of the dwelling corresponding to each head of household respondent. Such questionnaires turned out to be statistically valid and reliable after their application in a selected pilot sample.

Table 1 shows more clearly the relationship of constructs that make up the study model, which in turn are part of the instruments mentioned in the previous paragraph.

Table 1 Constructs of the study model

			Variables	
	Dimensions	**Subdimensions**	**HQI**[b]	**HQS**[c]
Housing Quality[a]	Housing-city relationship	Housing centrality relationship	I_1	P_1, P_2
		Home-work relationship	I_2	P_3, P_4
		Housing-services relationship	I_3	P_5, P_6
		Zoning-land use-mobility	I_4	P_7-P_{11}
	Housing-environment relationship	Physical-spatial	I_5	P_{12}-P_{31}
		Social	I_6	P_{32}
		Physical environmental	I_7	P_{33}-P_{35}
		Image-identify	I_8	P_{36}-P_{39}
	Characteristics of the house (habitable space)	Functionality and spatiality: space	I_9	P_{40}-P_{45}
		Functionality and spatiality: comfort	I_{10}	P_{46}-P_{53}
		Functionality and spatiality: form	I_{11}	P_{54}, P_{55}
		Economic aspects	I_{12}	P_{56}, P_{57}
		Technical- constructive aspects	I_{13}	P_{58}-P_{67}

Note: HQI: housing quality index; HQS: satisfaction with the quality of the home. Adapted from "Bases for the design of social housing: according to the needs and expectations of users", by A. L. Pérez, 2013, Bogotá, Colombia: Ediciones Unisalle.

[a]It is the variable that gives rise to the new HQI and HQS variables. [b]It is calculated using thirteen items that are valued with points that vary from 0 to 5. [c]It is calculated by responding to sixty-seven questions valued within a Likert-type satisfaction scale that varies from 1 to 5.

An intentional non-probabilistic sampling was carried out (also called convenience sampling), due to the limitation to have a sampling frame and the economic coverage to collect total information by the PAPI method (traditional pencil and paper method). In this way, a sample of 919 heads of households was established and taken, supported by the stratified sampling technique with proportional allocation, despite the fact that the original sampling technique is different, since there is no history of sampling with a similar scenario as a reference.

The process of applying questionnaires for data collection was carried out through a combination of several methods: PAPI (traditional pencil and paper method), CAWI (filling in the questionnaire through the web) and, by telephone (simulation of interview), and some requests for information from the head of the household via email.

The method of Selecting an Arbitrary Point on the Scale was proposed and applied for the construction of the Housing Quality Index (HQI). Likewise, the statistical techniques of

Correlation and Multiple Linear Regression were used to determine the relationship between both variables (Gujarati and Porter, 2009; Montgomery, 2005).

2.1. The Proposed Method of Selecting an Arbitrary Point on the Scale

The Method of Selection of an Arbitrary Point on the Scale was designed, because the need arises to find a way to build a robust Housing Quality Index before the manipulations caused by the researcher himself at the time of establishing it, and also, those of the specialist who will make use of it in the field; which are translated into terms of statistical error that harm the sensible estimation of the index and its possible extrapolation to the future. That is, the method is intended to build an index that is not affected by any bias of the researcher to define the index scales and the objective evaluations that each of these may have. Likewise, the model that supports the index can considerably control what the field specialist could undervalue or overvalue in terms of any of its component dimensions.

The Method of Selecting an Arbitrary Point on the Scale allows the index to be constructed by the researcher, based on his preparation and experience regarding the subject that gives life to the index; be evaluated in a more demanding way (controlling for biases), but preserving the assessment scales originally proposed by it.

Undoubtedly, the method does not restrict that initially the researcher intervenes in the general logic of the evaluation that the index carries out to determine the quality of a home, but from now on the method itself is who independently executes the final evaluation of it.

Four scales were proposed that place the Housing Quality Index, the same ones shown in table 2.

Table 2 Housing quality index (HQI) scales

	Scale	Interval	Score
HQI	Deficient	[0 ; 0.55>	0
	Acceptable	[0.55 ; 0.70>	1
	High	[0.70 ; 0.85>	2
	Higher	[0.85 ; 1]	3

Note: the housing quality index is a value that varies from zero (absence of quality) to one (total presence of quality).

The scales created will allow in this way to diagnose the situation of the quality of a particular home, after estimating it with data collected in the field. That is, the scales guide in many decisive aspects at the macro and micro level.

Additionally, each scale was scored with consecutive evaluations starting from zero (lack of quality), moving forward by one unit; in such a way that, a poor HQI registers 0 points, an acceptable HQI registers 1 point, a high HQI registers 2 points and a higher HQI registers 3 points. Such scores favor the elaboration of simple logical simulations of the behavior of the index against its components, which are used to recalculate the weights that the components contribute to the index.

To carry out the application of the method, it was also necessary to specify an "arbitrary field" or field of variation where the arbitrary value to be chosen within the scale of the components of the index is located. Such an arbitrary field is bounded, mainly, by a critical point at its lower end, which divides the deficient valuation zone below it from the acceptable zone above it. Being for this case the arbitrary point selected the score 3 (figure 1).

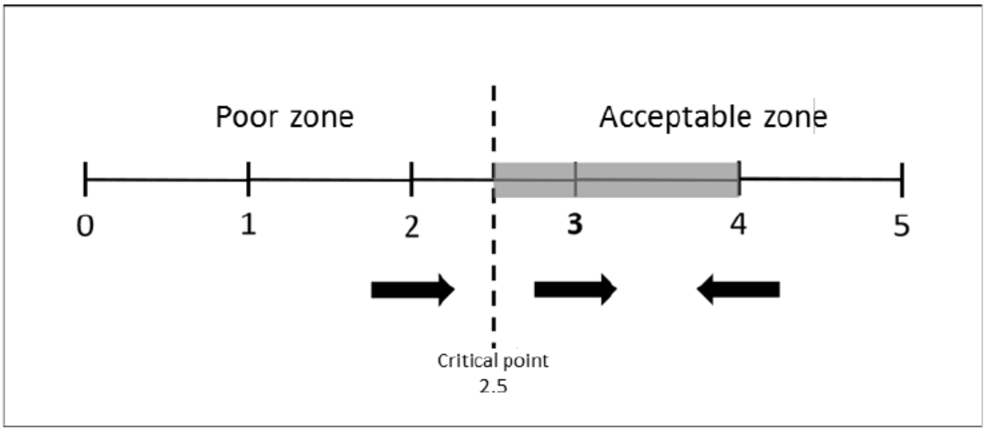

Figure 1. Determination of the field of variation where the arbitrary value is located within the scale. The gray shadow represents the defined field of variation, bounded below by the critical point 2.5 and above by the score 4. The black arrows indicate that the arbitrary value is selected from a position far from the extremes that define its field of variation.

The selection of an arbitrary point on the scale of the components offers the researcher the possibility of focusing only on three objective positions when performing the simulations of these against the index, without having to replace the original scale as was done with the index. In this case, zero will indicate the absence of component (0), five will indicate the total presence of component (5) and three will indicate the partial presence of component (3).

The method proposes the application of a simple linear regression with all the simulations carried out, in order to detect new weights for the components through adjustment, which are re-expressed in their equivalence in number of questions proportionally; not without first having grouped the dimensions of less relevance and leaving the ones of greater relevance free. With this, it was possible to define the model for estimating the Housing Quality Index (HQI) adjusted by the new weights that each dimension contributes to it. Thus, the model was as follows:

$$\mathrm{ICV} = \frac{I_1 + I_2 + I_3 + 10.\,I_4 + I_5 + I_6 + 9.\,I_7 + I_8 + I_9 + I_{10} + I_{11} + I_{12} + 16.\,I_{13}}{45 \times 13}$$

Where,

I1: housing-centrality relationship; I2: home-work relationship; I3: housing-services relationship; I4: zoning-land use-mobility; I5: physical-spatial; I6: social; I7: physical-environmental; I8: image-identity; I9: functionality and spatiality-space; I10: functionality and spatiality-comfort; I11: functionality and spatiality-form; I12: economic aspects; I13: technical-constructive aspects.

In the equation, note that the components with less relevance were expressed with their original weights, while the components with greater relevance were re-expressed with multiplied weights. So much so that components I4 (zoning-land use-mobility), I7 (physical-environmental), and I13 (technical-constructive aspects) respectively weigh 10, 9, and 16 times what they originally weighed.

Table 3 shows the evaluations recorded by the thirteen components of the Housing Quality Index for six selected observations. Likewise, they accompany the adjusted and unadjusted indices. In this comparative way, it is intended to demonstrate the effectiveness of the application of the Method of Selection of an Arbitrary Point on the Scale.

Table 3 Comparison of a normal HQI versus a method-adjusted HQI

N°	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	I_{11}	I_{12}	I_{13}	HQI	HQI A
48	5	3	5	1	2	4	1	4	2	1	3	5	0	.55	.27
318	3	3	4	4	2	3	5	2	4	2	4	4	4	.68	.90
430	1	1	2	1	2	2	2	1	4	2	4	2	2	.40	.41
697	1	3	2	0	2	2	1	3	4	3	4	3	0	.43	.18
702	1	3	2	0	2	2	1	3	4	3	4	3	0	.73	.18
913	4	4	5	4	4	5	1	4	4	4	4	5	0	.74	.46

Note: N °: observation number; HQI: index of quality of housing without adjustment; HQIA: quality index of tight housing.

The simple indices estimated for observations number 48, 702, and 913, registered scores of 0.55, 0.73, and 0.74 respectively, placing the first in an acceptable quality of housing index and the remaining two in a high index. While, for these same records, their adjusted indices were 0.27, 0.18, and 0.46 points respectively; reflecting in this way, a notable displacement of the quality of housing for these observations, placing them in a position of poor quality. Note that the adjusted index of observation number 702 showed a more dramatic change, due to the high difference that it has with respect to its simple index.

The above comparison allows us to check the approximation of the index adjusted to its real value, but not before noticing that, by theory and logic, it is not possible that the quality index of a home is acceptable or more than acceptable when its component I13 (aspects technical-constructive) is absent, or in other words, its evaluation turns out to be zero; which the simple index places erroneously when assuming all the components with equal competences, while the adjusted index does not.

Additionally, table 3 shows observations number 318, 430, and 697, which recorded simple housing quality indices of 0.68, 0.40, and 0.43 points respectively; and adjusted indices of 0.90, 0.41, and 0.18 points respectively. Note in such a way that for observation number 318, the housing quality index is relocated from an acceptable position to a higher one, due to the fact that the three components with the greatest contribution to it, register valuations no less than 4. Meanwhile, for the In the case of observations number 430 and 697, the situation of the index remains in the same poor position.

Although it is true, observation number 697 maintains its quality index in the same position, this being deficient; It can be verified that the score recorded by the index falls with some force because component I13 (technical-constructive aspects) is absent. Likewise, it can be noted that the simple and adjusted indices of observation number 430 present a negligible difference, validating this because the components registered low valuations.

3. RESULTS

3.1. Head of Household Profile

Regarding the profile of the head of household surveyed, it can be specified that:

59% of the participants are male and the remaining 41% female; the majority with ages between 18 and 34 years (77.2%) and a greater concentration (54.5%) between 25 and 34 years. 59.1% stated that they had obtained university as the last degree of instruction, while 13.6% stated that they had obtained technical as the last degree of instruction. Likewise, 24.2% and 3.1% respectively showed basic and postgraduate levels of instruction.

The majority of household heads (82%) reside in formal areas, among urbanizations, cooperatives and associations, while the minority (18%) reside in informal areas such as youth towns and human settlements. 59.1% of heads of household reside in single-family homes, 31.8% in multi-family homes and 9.1% in two-family homes.

3.2. Object Variables

The quality indices of the dwellings of the surveyed heads of households were estimated, finding the following distribution: 27.5% with high HQI, 18.4% with acceptable HQI and 54.1% with poor HQI. Likewise, according to the location of the dwellings, most of the dwellings have acceptable quality indices in the Central Lima areas with an average score of 0.62 points, in North Lima with 0.57 points and East Lima with 0.56 points. Meanwhile, it can be seen that South Lima scored a poor quality index of 0.45 points on average, and Modern Lima a high index of 0.80 points on average.

Note that the calculated indices do not necessarily allow their generalization within the corresponding area, in addition, it would be necessary to observe well and analyze each of the values mentioned above; for example, in North Lima and East Lima an HQI of 0.57 and 0.56 that despite not being far from the limit between a deficient level and an acceptable level (0.55), both values correspond to an acceptable level of quality. In other words, if the indices produced were necessary to make a decision (management), it would be appropriate to consult the database on how high, if it is high, or how acceptable, if it is acceptable, is the level of quality of the dwellings in any area (table 4).

The satisfaction of the heads of household with the quality of their dwellings was identified according to three defined dimensions. Regarding the dimension Housing-City Relationship (X1), North Lima and South Lima presented the lowest scores (27.41 and 26.32 respectively), taking as reference their corresponding comparative values (table 4). East Lima, North Lima and South Lima registered the lowest scores regarding the Housing-Environment Relationship dimension (X2), taking as a reference their corresponding comparative values, with 74.58, 75.31 and 64.60 points respectively. Finally, Lima Sur obtained the lowest score, 63.77 points, in the dimension Housing Characteristics (X3), taking into account its corresponding comparative value.

Table 4 Estimation of the representative housing quality index (HQI) by area of residence

		Central Lima	**East Lima**	**Modern Lima**	**North Lima**	**South Lima**
	Frequency	77	271	114	261	196
HQI	Average	.62	.56	.80	.57	.45
	Classification	Acceptable	Acceptable	High	Acceptable	Deficient
X1	Average	38.53 [a]	34.56[a]	30.18 [a]	27.41[a]	26.32[a]
	Comparative	.70 [b]	.63[b]	.55[b]	.50[b]	.48[b]
X2	Average	88.52 [a]	74.58[a]	103.06 [a]	75.31[a]	64.60[a]
	Comparative	.63 [b]	.53[b]	.74[b]	.54[b]	.46 [b]
X3	Average	86.90 [a]	80.20[a]	113.94 [a]	104.03 [a]	63.77[a]
	Comparative	.62 [b]	.57[b]	.81[b]	.74[b]	.46 [b]

Note: HQI: housing quality index; X1: housing-city relationship; X2: home-environment relationship; X3: characteristics of the home. [a]Average HQS score. [b]It was calculated taking the average score recorded by the dimension, with respect to the maximum score that the dimension could score if its HQS were perfect (maximum score calculated using the proposed method of selecting an arbitrary point on the scale).

It was observed that most of the areas of residence concentrate over 50% of homes with poor quality indices (low HQI) evaluating the Q2 and Q3 quartiles (table 5). East Lima scored a Q2 of 0.400 and a Q3 of 0.702, meaning that 50% of the homes studied in the sector scored deficient indices, below 0.400; likewise, the next 25% scored indices below 0.702, between poor and acceptable. Similarly, North Lima scored with a Q2 of 0.345 and a Q3 of 0.632.

Meanwhile, South Lima scored a Q2 of 0.177 and a Q3 of 0.354, being the most critical scenario, since 75% of the homes studied in the sector scored deficient indexes, below 0.354.

Table 5 Detail of the housing quality index (HQI) according to area of residence

	Central Lima	**East Lima**	**Modern Lima**	**North Lima**	**South Lima**
Average	.62	.56	.80	.57	.45
Standard deviation	.138	.234	.073	.216	.169
Q2	.618	.400	.784	.345	.177
Q3	.709	.702	.827	.632	.354

Note: Q2: quartile two or median; Q3: quartile three.

3.3. Diagnosis of Viability of the Multiple Linear Regression Model

A general analysis of the recorded data was carried out, in order to verify the randomness and normality of these, in such a way that the viability of the adjustment of the Linear Regression model can be determined and this allows testing the existing relationship between the Housing Quality Index variables and dimensions of Housing Quality Satisfaction. Note that compliance with the aforementioned requirements allowed a good fit of the model on the data, guaranteeing a good estimation of the variable under study with low levels of error, that is, the predictions obtained are more accurate.

To verify the randomness of the data, the Runs test was applied, which allowed the contrast of Hypothesis zero (H0): the HQI variable is random, compared to Hypothesis one (H1): the HQI variable is not random. The significance value of the test was 0.600, the same that exceeds 0.05 (chosen discrepancy value). Due to this, the zero hypothesis was accepted, that is, the test determined that there is no significant evidence to say that the indices were not obtained from a random data collection or have been manipulated.

It happened to demonstrate the normality of the main study variables (HQI and HQS) and of the dimensions of Satisfaction by Housing Quality, in such a way that the Kolmogorov-Smirnov test was used. Based on this, Hypothesis zero (H0) was contrasted: the variable has a normal distribution, compared to Hypothesis one (H1): the variable has no normal distribution. The test yielded significance values below the established discrepancy value of 0.05 for all variables, evidencing the lack of normality.

It is well known that it is extremely important that the variables comply with belonging to a population with a normal or approximately normal distribution in order to make a good fit of the model (Regression). However, it is possible to perform an analysis of the correlations between the variables by comparing a parametric test (assuming that the requirements for its execution are met) with a non-parametric one (it does not require compliance with requirements) and thus be able to know how much the correlations estimated with both techniques differ. If no relevance arises between the differences in the correlations found with both tests and they are linearly acceptable, the model can be adjusted.

It is important to emphasize that the data are prone to not passing the test of the assumption of normality because the percentage of low indices are greater than those of high indices, an almost frequent behavior in studies of social indicators.

The correlation levels between the study variables were evaluated, first considering Pearson's parametric technique, which despite not having been tested the necessary requirements to carry out the technique, was calculated and compared with the levels of correlation obtained by a second, non-parametric technique, Spearman's Rho. The purpose of comparison allowed us to decide how appropriate it is to adjust a linear model on the data. The correlations calculated using both techniques were found to be identical, with acceptable and significant correlation values.

The Pearson Correlations calculated among all the variables, one to another, resulted in a low (significant) linear correlation of 0.159 points between the Housing Quality Index and the dimension X1 of Housing Quality Satisfaction (table 6). Note that, in contrast to this, the Housing Quality Index presented high (significant) correlations of 0.604 and 0.574 points against the X2 and X3 dimensions of Housing Quality Satisfaction, respectively.

Table 6 Pearson correlations

		HQI	**HQS**	**X1**	**X2**	**X3**
HQI	Pearson c.	1	.683	.159	.604	.574
	P value		.000	.000	.000	.000
HQS	Pearson c.	.683	1	.228	.776	.904
	P value	.000		.000	.000	.000
X1	Pearson c.	.159	.228	1	.241	-.008
	P value	.000	.000		.000	.799
X2	Pearson c.	.604	.776	.241	1	.457
	P value	.000	.000	.000		.000
X3	Pearson c.	.574	.904	-.008	.457	1
	P value	.000	.000	.799	.000	

Note: HQI: housing quality index; HQS: satisfaction with quality of housing; X1: housing-city relationship; X2: home-environment relationship; X3: characteristics of the home.

It should be mentioned that the low correlation between the Housing Quality Index and the first dimension of Housing Quality Satisfaction does not mean that there is no linear correlation between the two, but it could be interpreted as a logical dissonance between both variables, due to that the knowledge of a professional knowledgeable in design, finishes and architecture provides assessments based on their professional practice, while the knowledge of a head of household provides assessments based on a perception that is not necessarily judged in consideration of professional knowledge in issues related to the related specialty to assess the quality of a home. Therefore, this difference would turn out to be non-significant, but it does exist and is translated into the low linear correlation.

Table 6 also shows the correlations between the dimensions of Housing Quality Satisfaction, one to another, resulting in correlations above -0.5 and below 0.5 points. The correlations in this case revealed a linear relationship, except for the X1 versus X3 correlation, which tended to zero, indicating the negligible linear correlation between them. This behavior was beneficial for the data fitting stage in the model, because it ensures negligible multicollinearity between the regressors, which is expected as one of the assumptions to validate the fit of the Linear Regression Model, since it is the dimensions that act as independent variables.

The correlations for the same crossing of variables were calculated using Spearman's non-parametric RHO method (table 7) and it was noted that the new scores comply with behaviors similar to those obtained by the previous procedure, which allowed to tolerate the conservative viability of the linear adjustment.

Table 7 Spearman correlations (Rho)

		HQI	HQS	X1	X2	X3
HQI	Spearman c.	1	.701	.150	.558	.614
	P value		.000	.000	.000	.000
HQS	Spearman c.	.701	1	.232	.702	.912
	P value	.000		.000	.000	.000
X1	Spearman c.	.150	.232	1	.246	.001
	P value	.000	.000		.000	.979
X2	Spearman c.	.558	.702	.246	1	.408
	P value	.000	.000	.000		.000
X3	Spearman c.	.614	.912	.001	.408	1
	P value	.000	.000	.979	.000	

Note: HQI: housing quality index; HQS: satisfaction with quality of housing; X1: housing-city relationship; X2: home-environment relationship; X3: characteristics of the home.

3.4. Estimation and Structural Test of the Multiple Linear Regression Model

After testing the feasibility of applying the linear model to the data, we proceeded to adjust it; For which, the variable Housing Quality Index was defined as a response variable or dependent variable and the dimensions of Satisfaction by Housing Quality, X1 (Housing-city relationship), X2 (Housing-environment ratio) and X3 (Characteristics of the dwelling-habitable space) as regressive variables or independent variables.

The fit of the data in the model was validated by applying the ANOVA test (Analysis of Variance), in such a way that the Zero Hypothesis (H0) was contrasted: The model is not explanatory ($\beta 0 = \beta 1 = \beta 2 = \beta 3 = 0$), compared to Hypothesis one (H1): The model is explanatory (at least one $\beta i \neq 0$). The test result yielded a significance value (0.00) lower than 0.05 (discrepancy value), allowing to reject the zero hypothesis. Meanwhile, it was concluded that the model is explanatory, that is, there is insufficient evidence to deny that the Housing Quality Index is explained by the regressive variables (dimensions of Housing Quality Satisfaction).

The estimates of the model parameters (betas: weights of each independent variable) were calculated and their respective significance levels were measured after applying the T-Student Test (table 8), in order to contrast the Zero Hypothesis (H0) : $\beta i = 0$ against Hypothesis one (H1): $\beta i \neq 0$. The test calculated the levels of significance for each of the parameters betas, 0.004, 0.011, 0.000 and 0.000 for the intercept, the dimension X1 (Housing-city relation), X2 (Housing-environment relation) and X3 (Housing characteristics). -habitable space) respectively, these values being less than 5% as the fixed discrepancy value, concluding that each estimated beta is significantly non-zero, that is, each dimension of the Satisfaction by Housing Quality has a significant contribution or weight on the variable response to the Housing Quality Index.

Table 8 Estimation of the coefficients of the model (dependent variable HQI)

	Non-stand. coefficient		Stand. coefficient		
	B	Tip. error	Beta	T	Sig.
(Constant)	-.092	.032		-2.906	.004
X1	.002	.001	.063	2.549	.011
X2	.005	.000	.413	14.808	.000
X3	.003	.000	.386	14.266	.000

Note: X1: house-city relationship; X2: home-environment relationship; X3: characteristics of the home; B: non-standardized beta coefficients; T: T-Student test; Sig: significance value.

The goodness of fit of the model was estimated through the Determination Coefficient (R squared), which scored 0.481, indicating that the model complies with explaining 48.1% of the variability of the Housing Quality Index. An R-squared of this magnitude may not be the most generous symptom of a superior or near perfect fit, but it reveals an acceptable composition of the variables, providing a good starting point for estimating a more sophisticated (polished) model in the future.

Finally, the adjusted model took the following form: $\hat{Y}i = -0.092 + 0.002\ X1 + 0.005\ X2 + 0.003\ X3 + \hat{\varepsilon}i$. Where $\hat{Y}i$ represents the dependent variable called the Housing Quality Index, X1 the Housing-City Relationship, X2 the Housing-Environment Ratio, X3 the Characteristics of the housing-habitable space and, $\hat{\varepsilon}i$ the Estimated Error. Being X1, X2 and X3 the dimensions of Satisfaction by Housing Quality, mentioned above.

As can be seen, the equation of the model has positive signs, mainly in the weights of the dimensions of Satisfaction by Housing Quality, except for the intercept. The negative intercept would indicate that, in the absence of all the regressive variables, the variable Housing Quality Index would take the value of -0.092, or simply 0. This value would have been a noise if it had taken a value further from the unit negatively, or perhaps much more distant, because it would have put into judgment the estimation of the parameters that make up the model. Meanwhile, the estimated model has parameters with expected signs according to the proposed theoretical model, then, when increasing by one unit any of the dimensions of Satisfaction by Housing Quality and, the rest remaining fixed, the variable Housing Quality will increase by as many units as the parameter or dimension represented weighs.

Having estimated the standardized coefficients of the model, it was possible to rank the dimensions of Satisfaction by Housing Quality. Thus, the Housing-Environment Relationship dimension topped the list (0.413 points), followed by the Housing Characteristics dimension (0.386 points) and, finally, the Housing-City Relationship dimension (0.063 points).

According to the scores obtained for each dimension, it could be presumed that the heads of households value more the relationship that the home has with the environment, when choosing a home, rather than value the home per se and each of its constructive benefits and comfort, or the relationship it has with the rest of the city.

3.5. Checking the Assumptions of the Multiple Linear Regression Model

As indicated by the Theory of Statistical Science, it is extremely important that the errors of the model comply with the assumptions of linearity, randomness, normality, homoscedasticity and independence, in order to conclude the good fit of the model (Gujarati and Porter, 2009).

The assumption of linearity of the errors was graphically verified, correlating the response variable (Housing Quality Index) and the standardized residuals. The graph (figure 2) showed a linear behavior with slight deviations that can be tolerated.

The Runs test was applied in order to verify that the errors did not present patterns of manipulation of the original data. In this way, Hypothesis zero: Errors are random was contrasted, versus Hypothesis one: Errors are not random. The test calculated a significance (0.08) greater than 5% defined as the discrepancy value, accepting the zero hypothesis; which allowed to verify the assumption of Randomness of the errors.

The assumption of Normality of the errors was demonstrated by applying the Kolmogorov-Smirnov test, by means of which the Zero Hypothesis was contrasted: The errors are distributed as a normal distribution, compared to Hypothesis one: The errors are not distributed as a normal distribution. The test scored a significance of 0.093, a value that exceeds the 5% established as a discrepancy. The significance value then allowed us to conclude that the errors are distributed as a normal distribution or at least there is no evidence to deny it.

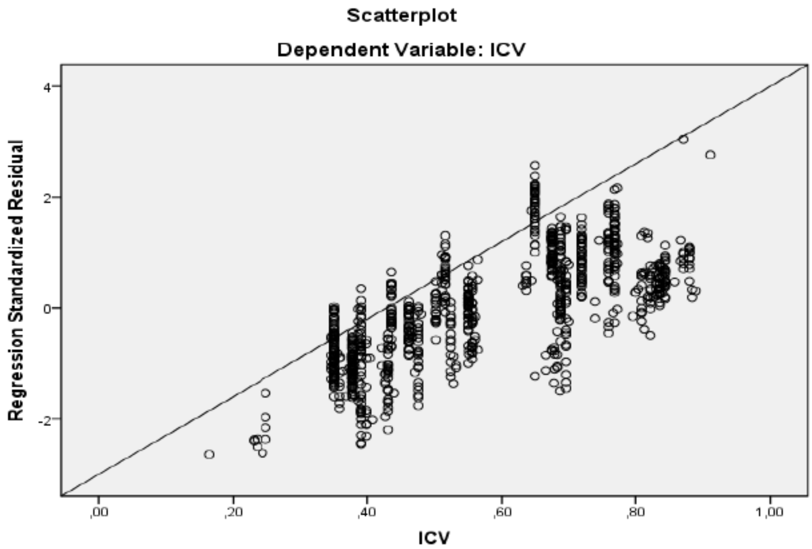

Figure 2. Correlation of the housing quality index (HQI) versus residuals standardized plotted with SPSS for Windows version 23.00 software.

To test the assumption of Homocedasticity or Homogeneity of Variances of the errors, a simple linear regression was calculated between the quadratic residual values of the Housing Quality Index and the regressive variables (dimensions of Housing Quality Satisfaction). Based on this, the ANOVA test was used and the Zero Hypothesis was contrasted: There is homogeneity of variances between the errors, compared to Hypothesis one: There is no homogeneity of variances between the errors. The ANOVA test yielded a significance value of 0.061, which is a value that exceeds 5% (established discrepancy value) and evidence of acceptance of the zero hypothesis. In other words, there is no evidence to deny the homogeneity of variances of the errors.

The Durbin-Watson test was used to test the assumption of Independence of the errors, allowing to contrast the Zero Hypothesis: There is no autocorrelation or, equivalently, the error terms are independent, compared to Hypothesis one: There is autocorrelation or, equivalently, the error terms are not independent. The value obtained by the Durbin-Watson test was 1,846.

To carry out the hypothesis contrast, the Durbin-Watson table (with alpha equal to 5%) was used in order to find a discrepancy interval to the statistic calculated by the test. Likewise, a k = 3 was set for n = 950, detecting dL = 1,889 and dU = 1,897. With these last two values, the two hypothesis testing bands were constructed, obtaining the positive autocorrelation interval [1,889, 1,897] and the negative autocorrelation interval [2,103, 2,111]. In such a way that, as the calculated Durbin-Watson statistic falls outside both autocorrelation intervals, the zero hypothesis is accepted, allowing to indicate that the error terms are independent.

Finally, it was proved that the Multiple Linear Regression model is valid for its fit in the data.

4. CONCLUSION

The research allowed to validate that the Satisfaction by Housing Quality is linearly related to the Housing Quality Index, without ruling out or validating the possible causality between both variables. For its detection, the Linear Regression model was used, unlike Arévalo (1999), who uses the multivariate technique of Correspondence Analysis to build the Housing Quality Index in Spain. Likewise, it is important to recognize that the research applied similar criteria to construct the Housing Quality Index in Metropolitan Lima, despite the fact that Arévalo developed the multivariate model to compare the housing of 1980 with that of 1990 and demonstrate that the quality has improved with over time.

It was verified that the dimensions of the housing-city relation, the housing-environment relation, and the characteristics of the dwelling (living space) have a positive linear relationship with the housing quality index.

The Multiple Linear Regression model made it possible to rank the linear relationship of the dimensions of satisfaction by quality of housing with the index of quality of housing, occupying the first place, the dimension housing-environment relation, the second place the characteristic dimension of housing (habitable space) and, finally, the housing-city relationship dimension.

The model applied in the research was validated using various criteria such as the prior analysis of the applicability of the linear model and the goodness of fit indicators, but finally and, perhaps more importantly, by analyzing the errors at a primary level. Despite this, it is possible to analyze each residual a little more to further refine and improve the estimated model and, when used, the projections are much more precise. In this exercise, it has not been seen convenient to delve into the analysis of residuals because the data collection was carried out considering a non-probabilistic sampling procedure, and for the level pursued by the investigation, the conclusions obtained from the procedure carried out are valid. . However, it is recommended to return to the research topic and recalculate the statistical model from data obtained under a probabilistic sampling design, in order to more accurately estimate the parameters of the Linear Regression model. In this way, the model will allow estimating more accurate indices at the time of its application.

The variable satisfaction by quality of housing was estimated from three dimensions that in turn are made up of items that collect information based on the perception of the respondent, while the variable index of quality of housing by three identical dimensions, but made up of indicators that collect objective information. In this way, and in accordance with García Pozo (2007), the model separates subjective from objective information and crosses them in order to highlight the relationship between the two. Meanwhile, Sánchez (2013) mixes both types of information to estimate two concepts and evaluate their relationship, the variables urban function and quality of housing.

It is recommended to use the proposed statistical model, in the appraisal of homes, the qualification of a head of household in the financial system (segmentation), as an indicator to measure the degree of vulnerability of its users, as an indicator of design quality, as an indicator of human development, and so on. However, it is advisable to use other more sophisticated models of Statistics in this type of research, such as the Canonical Correlation model, which allows with greater ambition to measure the different relationships that the dimensions of both study variables may have: HQI and HQS.

In addition, it is important to also consider updating the statistical model in a period of no more than 5 years due to the constant changes of known and unknown exogenous variables. Mainly because there is a rapid trend towards the reduction of square meters of the new homes offered, which are replacing those single-family homes of greater extension (in the absence of space to build horizontally), causing the population to adopt new habits. It is also recommended that the proposed statistical model serve as a reference for further research.

The research determined the profile of the head of the household surveyed: he is male, 25 to 34 years old, his highest level of education attained is university, resides in an urbanization, cooperative or association in a single-family dwelling.

The proportion of heads of households satisfied with the quality of housing was estimated to be 0.5658, with a limit for the estimation error of ± 0.0496. Also, the estimated proportion of homes with passing quality indices is 0.4592, with a limit for the estimation error of ± 0.0447. The difference between the two indicators, being a little more satisfaction, can be interpreted as reasonable since the indicator was measured through a subjective evaluation carried out by the head of household of the dwelling, who generally overestimates his perception of reality by several reasons, mainly for fear of being judged; instead, the quality of the home is a more controlled indicator and is based on the objective analysis carried out by the Specialist.

Finally, it is recommended that this research be used as a reference model for quantitative research with advanced Statistics applied to research in the specialty of Architecture.

REFERENCES

[1] Arévalo-Tomé, R. (1999). “Construcción de un índice de calidad de la vivienda”. Investigaciones económicas, 23(2), 267-280. Recovered from HIPERLINK https://www.researchgate.net/publication/5108273_Construccion_de_un_indice_de_calidad_de_la_vivienda

[2] Ávila, R. (2000). Estadística Elemental. Lima: Estudios y Ediciones R.A.

[3] Cattaneo, M., Galiani, S., Gertler, P., Martinez, S., & Titiunik, R. (2009). “Housing, Health, and Happiness”. American Economic Journal: Economic Policy, 1(1), 75-105. doi: 10.1257/pol.1.1.75

[4] Cortada De Kohan, Nuria (2001). Constructos Psicológicos y Variables. Buenos Aires, Argentina: Universidad del Salvador. Recovered from HYPERLINK http://psico.usal.edu.ar/psico/constructos-psicologicos-variables

[5] [5] D'agiout, G. T. (15 de diciembre de 2006). “Per un'epistemologia dell'architettura”. Àgora di filosofia. Recovered from HYPERLINK https://bit.ly/2MiHOSe

[6] Davis, M. (1994). “Cannibal City: Los Angeles and the Destruction of Nature”. En E. Smith, Urban Revisions: Current Projects for the Public Realm (págs. 39-57). Los Angeles, CA: Museo de Arte Contemporáneo y Cambridge MIT Press.

[7] Dwan, D., Sawicki, M., & Wong, J. (2013). “Subdivided Housing Issues of Hong Kong: Causes and Solutions. An Interactive Qualifying Project”. Hong Kong Institute of Education, Social and Human Services. Hong Kong: Worcester Polytechnic Institute. Recovered from https://bit.ly/2e7y9gG

[8] EL COMERCIO. (21 de septiembre de 2014). “El 60% de las viviendas de Lima son vulnerables a sismos”. Redacción El Comercio. Recovered from HIPERLINK https://bit.ly/2IzRnrU

[9] García Pozo, A. (2007). “Una aproximación a la aplicación de la metodología hedónica: especial referencia al caso del mercado de la vivienda”. Cuadernos de CC.EE. y EE(53), 53-81.

[10] GESTIÓN. (07 de agosto de 2013). “Sencico: Un 60% de viviendas en el Perú es autoconstruida”. Redacción Gestión. Recovered from HYPERLINK https://bit.ly/2Yj0AQn

[11] Gifford, R. (2007). Environmental psychology: principles and practice (Fourth ed.). Colville, WA: Optimal books.

[12] Graizbord, B. (2007). “Megaciudades, globalización y viabilidad urbana”. Investigaciones geográficas (63), 125-140. Recovered from HYPERLINK http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-46112007000200009

[13] Gujarati, D., & Porter, D. (2009). Econometría (Quinta ed.). México DF, México: Mc Graw Hill.

[14] Hancevic, P., & Navajas, F. (2015). “Consumo residencial de electricidad y eficiencia energética”. El trimestre económico, 82(4), 897-927. Recovered from HYPERLINK http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2448-718X2015000400897

[15] Hernández, R. (2014). Metodología de la Investigación. México DF, México: Mc Graw Hill.

[16] Juran, J., & Gryna, F. (2005). Manual de control de la calidad. Barcelona, España: Reverté.

[17] Macip, R. (2008). “Clase y discriminación”. Ciencia, 59(2), 23-31. Recovered from HYPERLINK https://www.revistaciencia.amc.edu.mx/images/revista/59_2/PDF/05-614-p23-31.pdf

[18] Maslow, A. H. (1991). Motivación y personalidad. Madrid, España: Ediciones Díaz de Santos.

[19] Montgomery, Douglas (2005). Introducción al Análisis de Regresión Lineal. México: Editorial CECSA.

[20] Oficina De Las Naciones Unidas (ONU) - HABITAT. (2010). El derecho a una vivienda adecuada. Ginebra, Suiza: Oficina de las Naciones Unidas en Ginebra, Oficina del Alto Comisionado de las Naciones Unidas para los Derechos Humanos. Recovered from HYPERLINK http://www.ohchr.org/Documents/Publications/FS21_rev_1_Housing_sp.pdf

[21] Pérez, C. (2010). Técnicas de muestreo estadístico. Madrid, España: Ibergaceta Publicaciones.

[22] Pérez P., A. L. (2013). Bases para el diseño de la vivienda de interés social: según las necesidades y expectativas de los usuarios. Bogotá, Colombia: Ediciones Unisalle.

[23] Reátegui Vela, A. I. (2015). Determinantes de la satisfacción familiar con la vivienda en segmentos de bajos ingresos: el rol del subsidio del estado. Catalunya, España: Escuela superior de administración y dirección de empresas (ESADE), Departamento de economía, finanzas, contabilidad y ciencias sociales.

[24] Rodríguez, A., & Sugranyes, A. (2004). “El problema de vivienda de los "con techo"”. Eure, 30(91), 53-65. Recovered from HYPERLINK https://scielo.conicyt.cl/scielo.php?script=sci_arttext&pid=S0250-71612004009100004

[25] Sabatini, F., Rasse, A., Cáceres, G., Robles, M. S., & Trebilcock, M. P. (2017). “Promotores inmobiliarios, gentrificación y segregación residencial en Santiago de Chile”. Revista Mexicana de Sociología, 79(2), 229-260. doi: http://dx.doi.org/10.22201/iis.01882503p.2017.2.57662

[26] Sánchez Arrastio, R. M. (2011). “La lógica Capitalista y la Vivienda”. Revista universitaria digital de ciencias sociales, 2(2), 1-36. Recovered from HYPERLINK http://virtual.cuautitlan.unam.mx/rudics/wp-content/uploads/2014/11/Rudics-n%C3%BAm.-2-art1.pdf

[27] Sánchez Barrera, J. C. (2015). Calidad de vivienda y función urbana en Lima Norte. Lima, Perú: Universidad Nacional Federico Villarreal (UNFV), Escuela Profesional de Matemática y Estadística. Recovered from HYPERLINK http://repositorio.unfv.edu.pe/handle/UNFV/1488

[28] Sánchez Estévez, R. (2013). “La significación de la casa y del habitar en dos grupos sociales en la Ciudad de México”. Cuicuilco, 20(56), 77-94. Recovered from HYPERLINK http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-16592013000100005

[29] Santana Rivas, L. D. (2013). Precariópolis y privatópolis en la región metropolitana de Bogotá (1990-2010). Un análisis socioespacial de los barrios cerrados. Bogotá, Colombia: Universidad Nacional de Colombia (UNC), Departamento de Geografía.

[30] Schteingart, M. (1979). "Sector inmobiliario capitalista y formas de apropiación del suelo urbano: el caso de México". Demografía y economía, 13(4), 449-466. doi: http://dx.doi.org/10.24201/edu.v13i04.424

[31] Soja, E. (2008). Postmetrópolis. Estudios críticos sobre las ciudades y las regiones. (V. Hendel, & M. Cifuentes, Trads.) Madrid, España: Traficantes de sueños.

[32] Soto-Cortés, J. J. (2015). "El crecimiento urbano de las ciudades: enfoques desarrollista, autoritario, neoliberal y sustentable". Paradigma económico, 7(1), 127-149. Recovered from HYPERLINK https://dialnet.unirioja.es/servlet/articulo?codigo=5926288

[33] Zubiri, X. (1998). Inteligencia sentiente. Inteligencia y realidad (Quinta ed.). Madrid, España: Alianza editorial.