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DEVELOPMENT AND VALIDATION OF THE HOUSING ENVIRONMENTAL QUALITY ASSESSMENT TOOL (HEQAT) FOR CHILDREN WITH ADHD USING THE DELPHI PROCESS

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This study aimed to establish a valid and purposeful evaluation tool for building professionals and designers to identify housing features that adversely impact children and adolescents with attention-deficit/hyperactivity disorder (ADHD). After a review of pre-existing tools, it was found that such a tool does not yet exist but is necessary for modifying, designing, and constructing residential environments of the future. Most environmental quality checklists or housing quality assessment tools lack specificity, development, and documentation of operational definitions. Therefore, we developed the Housing Environmental Quality Assessment Tool (HEQAT) based on pre-existing building tools in combination with identified aspects of environmental features associated with mental health and ADHD extracted from the literature. Using the Delphi process, we modified the tool based on the opinions of four groups of experts and stakeholders to establish the tool's validity. The Content Validity Index (CVI) was used to establish the overall content validity of the assessment tool. Of the tool's 74 items reviewed and rated by a team of experts and stakeholders over a 2-round Delphi process, 70 items were judged to be relevant, with a CVI of greater than 0.78. Consequently, the tool's overall content validity was calculated as 95 per cent. The data obtained using this tool could contribute to the knowledge of how residential buildings can be designed and built to be suitable for individuals diagnosed with ADHD.

Keywords: **attention-deficit/hyperactivity disorder, post-occupancy evaluation, expert panel and stakeholders, indoor environmental quality, Content Validity Index.**

INTRODUCTION

Significance of the study

Attention-deficit/hyperactivity disorder (ADHD) is a chronic neurodevelopmental disorder that has its onset in childhood and mostly continues into adulthood (APA, 1994; Faraone *et al*., 2003; Mayo Clinic, 2019). The prevalence of ADHD is increasing worldwide (Geng, 2011). A meta-regression analysis of international epidemiological research has shown a growth in ADHD prevalence from 5.3% in 2007 (Polanczyk *et al*., 2007) to 7.2% (roughly 129 million) in 2015 (Thomas *et al*., 2015) among children and adolescents aged 18 and under. In Australia, with the 12-month prevalence of ADHD in 2013-2014 estimated at 7.4%, it is also the most widespread mental health condition in children aged 4-17 (Lawrence *et al*., 2015).

Meanwhile, due to urbanisation and the modern lifestyle, children spend most of their time indoors (70%-75%), and their growth and development occur predominantly within their homes (Höppe, 2002; Mendell and Heath, 2005). Since a home is the most important place of human habitation

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(Kurian and Thampuran, 2011), the environmental quality of housing may significantly impact children's health and activities performed within their homes (Boch *et al*., 2021; Wells *et al*., 2010).

While there are some studies in the literature on building features and quality in the context of ADHD, scientific and theoretical investigations on the impact of housing environmental quality on childhood ADHD are lacking. Also, there are limited tools for assessing the environmental quality of housing for children in general. The fact that children are rarely considered in the current array of built environment assessments lends extra evidence to the point that children with ADHD or other specific health conditions are not usually considered within the context of designing homes and buildings. Particularly, no tool currently exists to specifically evaluate the housing quality of children diagnosed with ADHD, a condition that is impacting a significant number of people worldwide.

BACKGROUND

Housing environmental quality, mental health, and ADHD

Environmental quality (EQ) is the composition of environmental components that interrelate with their users (Vischer, 1989). EQ can also be referred to as the quality of a building's environment for its inhabitants (NIOSH, 2013). Therefore, housing environmental quality can be described as the assessment of the main features impacting the comfort, health, and wellbeing of the inhabitants (Garnys, 2007), and parameters to create an environment that is healthy for residents in both physical and psychological aspects (Bonda and Sosnowchik, 2007). There is a growing concern surrounding housing environmental quality (Yoon, 2008), and therefore, it is essential to assess and manage the environmental quality of housing and residential buildings.

Housing quality and the built environment can influence human health and mental wellbeing (Palacios *et al*., 2021). People living in better-quality housing have fewer psychological symptoms (Wells *et al*., 2010). The evidence for this involves cross-sectional investigations of individuals randomly assigned to different housing conditions, with controls for socioeconomic status and longitudinal comparisons before and after housing improvements (Evans *et al*., 2000; Evans *et al*., 2003). Additionally, the results of a quasi-experimental study in public housing suggested that housing quality can enhance residents' health and psychological wellbeing (Vaid and Evans, 2017). Boch *et al*. (2021) reported that after adjusting for demographic characteristics (ethnicity, race, and disability), and controlling for housing-related issues (difficulty with rental payments or neighbourhood safety), poor housing quality had independently contributed to poorer health conditions and an increase in the number of medical visits for children.

Evidence-based design research on healthcare buildings has demonstrated the impact of the built environment on its users in terms of a reduction in infection and stress, and improvement in patient comfort (Alfonsi *et al*., 2014). Ulrich (1984) pioneered such research, observing that viewing nature from a hospital window had more positive effects on improving the recovery process in patients. Concerning the impact of a built environment based on housing during the COVID-19 lockdown, research has shown that mental health issues including depression and anxiety were strongly associated with poor housing quality (Amerio *et al*., 2022; Morganti *et al*., 2022).

Additionally, architectural renovations and housing quality parameters, including maintenance and upkeep, layout and structural quality, cleanliness, and amenities and private spaces, are associated with improved mental health outcomes (Evans *et al*., 1996; Freeman, 1984). Specifically, it was revealed that layout, spatial sequencing, and simple interior architectural design contribute to better attention and behaviour in children with ADHD and autism spectrum disorder (ASD) (Alkahtany, 2014; Mostafa, 2008; Tufvesson, 2007). In the school setting, a greater number of openings (i.e., having several windows and entrance doors into the classroom) caused more distractions and negatively impacted a child's ability to concentrate (Tufvesson, 2007).

Accordingly, relevant literature has shown the effects of housing scale, in terms of type, height or floor level, size, and access, on residents' mental health (e.g., Evans, 2003; Fanning, 1967). It was also found that children residing in large 14-level public housing compared with children residing in three-level public housing had significantly greater behavioural problems (Saegert, 2013). Specifically, research revealed that families living in council housing were more likely to have a child with ADHD, albeit this association was mediated by financial difficulties (Russell *et al*., 2015).

The literature also highlights links between ADHD in children with income or economic issues within their family, mainly because more families of children with ADHD report living in poverty or having financial difficulties (e.g., Rowland *et al*., 2018; Russell *et al*., 2016). For instance, Miller *et al*. (2018) demonstrated that the diagnosis of moderate or severe ADHD symptoms was more likely among children from families under 200% of the US government's poverty line compared with children above that line. Russell *et al*. (2016) showed that housing tenure was also significantly associated with ADHD.

Regarding the indoor environmental quality, factors such as acoustic quality, air quality, lighting quality, and thermal comfort revealed a significant association with mental health. Specifically, previous research has shown that low acoustic quality and noise adversely influenced children's psychological wellbeing (Bullinger *et al*., 1999; Lercher *et al*., 2002) and caused inattention and misbehaviour in children with ADHD and ASD (McAllister and Maguire, 2012; Mostafa, 2008; Tufvesson and Tufvesson, 2009). Research has also linked the development of neurological disorders, learning disabilities, and cognitive deficits (e.g., ADHD and ASD) with exposure to environmental pollutants and toxic chemicals (e.g., IQAir, 2021; Needleman *et al*., 1990; Silver, 2022). More specifically, it has been found that children exposed to traffic-related air pollution are more likely to develop hyperactivity symptoms (Newman *et al*., 2013).

Other studies have revealed that daylight (Arns *et al*., 2013; Küller, 2002) and artificial light (Küller, 2004; Küller and Laike, 1998) affect children's behaviour and concentration.

Too much daylight or direct natural lighting can increase distraction and impair a child's performance, especially at school (Tufvesson and Tufvesson, 2009). Many autism-friendly design guidelines have also referred to the avoidance of fluorescent lighting and glare (Beaver, 2010; Vázquez and Torres, 2013; Vogel, 2008). Moreover, studies have shown that poor temperature (heating and cooling conditioning) and humidity levels reduce attention span, resulting in poorer learning conditions, achievement, and task performance (King and Marans, 1979; McGuffey, 1982).

The literature also emphasises the significance of neighbourhood quality. Lower neighbourhood support has been linked with increased ADHD diagnosis and severity (Razani *et al*., 2015). Additionally, neighbourhood socioeconomic disadvantage has also been significantly associated with increased utilisation of ADHD medication in children (Jablonska *et al*., 2020). Studies of ADHD-friendly design have shown that interior furnishing design, furniture arrangement, space decoration, pattern and texture, material, and colour are associated with an ADHD diagnosis in children and their ability to concentrate (Henry, 2011; McAllister and Maguire, 2012; Tufvesson, 2007).

Having demonstrated the significance of various housing attributes to residents' mental health and, more specifically, the prevalence of ADHD among children and adolescents, the availability of a focused assessment tool is essential to evaluate the quality of the housing environment of individuals with ADHD.

Issues with pre-existing assessment tools

A literature review was conducted on the established pre-existing building assessment tools using databases, such as Google Scholar, Scopus, and Web of Science. The search keywords included building tool, building survey, post-occupancy evaluation tool, environmental quality survey, built environment survey, design quality tool, home, housing, or residential building assessment tool, and attention deficit hyperactivity disorder or ADHD.

It was concluded that a housing assessment tool for ADHD does not yet exist which would be potentially instrumental in modifying, designing, and constructing residential environments of the future. Most environmental quality checklists or housing quality assessment tools lack specificity or the development of operational definitions. For example, building commissioning assessment tools apply to the stage between the end of construction and the beginning of occupancy. For that reason, these types of tools are primarily inapplicable for this study. Post-occupancy evaluation tools are used for the stage after the building is occupied; therefore, they are more appropriate for this study. However, post-occupancy tools are generally specific to a single building or a single type of building; therefore, they may not give good exploratory insight into various residential buildings. Most importantly, none of these surveys yields specific data of interest, particularly about the suitability of housing features for ADHD. A suitable tool for assessing the quality of the housing environment of individuals with ADHD is required to meet the following conditions:

- Applicable for evaluation of existing buildings (e.g., post-occupancy evaluation tools);
- Applicable for assessment of all types of residential dwellings (i.e., single-family housings and multi-unit residential buildings);
- Suitable to be answered by building occupants and non-experts (e.g., occupant satisfaction survey);
- No requirement for physical measurement or on-site data collection of the building by an expert;
- Covering criteria for evaluating buildings' indoor environmental quality (IEQ); and
- Suitable for evaluating the housing quality for individuals diagnosed with ADHD.

With regard to the above-mentioned conditions, the most commonly cited assessment tools in building evaluation-related research published between 2003 and 2019 were reviewed and compared (e.g., Boonstra and Pettersen, 2003; Choi, 2011; Ilha *et al*., 2009; Lee, 2007; Li *et al*., 2018; Meir *et al*., 2009; Nag, 2019; Ng, 2011; Noble, 2018; Peretti and Schiavon, 2011; Radwan, 2014; Sanni-Anibire *et al*., 2016; Shahrokhi *et al*., 2016; Soccio, 2016; Spetic, 2003; Tinner, 2016; Wilkinson *et al*., 2018; Woo, 2010; Yoon, 2008; Zagreus *et al*., 2004). Table 1 shows the comparison among these well-known building assessment tools regarding coverage of the relevant conditions. As the table shows, none of these pre-existing assessment tools covers all the required items and clinical conditions.

Table 1. The comparison of pre-existing building assessment tools regarding their suitability for evaluation of housing quality for individuals with ADHD

Tool name	Suitable for existing buildings	Suitable for housing and residential buildings		Including occupant satisfaction survey	No requirement for physical measurement/ on-site data collection by an expert	Assessing IEQ	ADHD coverage
		Single-family housing	Multi-unit residential building				
Green Star							
LEED							
BREEAM							
CASBEE							
GBTool							
EcoHomes							
HQE							

CBE IEQ							
BUS							
NEAT							
B3-SPOES							
NABERS							
TOBUS							
BOSSA							
iiSBE							
PROBE							
HQI							
BASE							
SIEQ							
DQI							
HOPE							
BOMA							
HK-BEAM							
SBTool							
B3-MSBG							

MATERIAL AND METHODS

Development of Housing Environmental Quality Assessment Tool (HEQAT)

While several tools exist for the measurement of ADHD and for assessing building quality, no existing tool was found in the literature that brings these two aspects together by meeting all the conditions mentioned above (Table 1). Therefore, we developed a new focused assessment tool (Appendix A). The initial hierarchical framework of the survey design was inspired by pre-existing building quality assessment tools (e.g., IEQ CBE). However, additional building quality variables were drawn from the literature review. Furthermore, the questions were adjusted to target all types of residential buildings (e.g., single-family housing, multi-unit residential dwellings). Adjustments were also made to allow for a more comprehensive evaluation of the building (rather than just IEQ) in combination with identified ADHD aspects and the built environment features extracted from the literature. Additional author-designed questions were added to enhance the interplay between ADHD and building features and to meet all the required assessment needs. Lastly, the opinions of experts and stakeholders were used for the final amendments and revision of the survey. As a result, a focused survey was developed to be inclusive and specifically target housing for individuals with ADHD. The study was conducted in Australia.

Indicators and assessment criteria of HEQAT

The focus of a post-occupancy evaluation tool can be organised into five general groups of building elements, including technical, functional, behavioural, symbolic, and economic factors (Blyth *et al*., 2006; Preiser *et al*., 1988). These consist of indicators representing signs, elements, and items that assess certain qualities of a building feature (Mustafa, 2017). Other authors have also proposed similar categorisations of building features (e.g., HPW, 2010; Sanni-Anibire *et al*., 2016).

Additionally, Spetic (2003) suggested that significant target areas for healthy housing design and use are the environment, the occupants, demographics, and socio-economics. Studying demographic and socio-economic factors is essential as such assessment tools are designed to be answered by occupants, and these characteristics of participants should be referred to while interpreting the data. Individual characteristics (age, gender, and marital status), and socio-economic factors (income, expenses, education, and employment), have been used in previous housing EQ-related research (e.g., Jiboye, 2012; Varady *et al*., 2001), given the impact of these variables. Therefore, these features and categories were considered in the design of our tool's indicators and assessment criteria.

In the design of our tool, *technical factors*, which are the indicators of a building's physical systems dealing with the survival attributes of its users (Preiser *et al*., 1988), comprised safety and security, interior condition and maintenance, structure and layout, and cleanliness. We used eight variables for the measurement of technical-related indicators, including the ratings of their suitability and checking for any relevant issues.

From an environmental viewpoint, technical factors also address the concerns of *indoor environmental quality* (IEQ) (Choi *et al*., 2012). IEQ comprises acoustic quality, (indoor) air quality, thermal comfort, and lighting quality in this tool. We used 13 variables for the measurement of IEQ-related indicators, including the ratings of their suitability, the level of controllability, and the existence of any relevant issues. Additionally, the direction of the windows of the home's main living area was considered for evaluating the quality of natural lighting and the amount of sunlight exposure available in the home.

Functional factors address the practicality and effectiveness of features and facilities in a building with spatial comfort (HPW, 2010; Preiser *et al*., 1988; Sanni-Anibire *et al*., 2016).

Therefore, they are categorised as *spatial factors* in this tool, comprising housing type, access type, size, and privacy. We used 10 variables for the measurement of spatial-related indicators including their types/size, suitability, and the existence of any relevant issues. For evaluating privacy, whether the child with ADHD resides in his/her bedroom or a shared bedroom was also considered. The information about home size was ascertained in the form of both conceptual (e.g., very small) and metric estimations of the floor area (e.g., less than 75m^2), as well as the number of bedrooms within the home.

Behavioural factors which connect residents' activities and the physical environment (Preiser *et al*., 1988) comprise crowding, residency, and indoor activity. We used five variables for the measurement of behavioural-related indicators. Crowding was measured based on the number of residents within a home setting and the ratio between the number of residents and bedrooms available in the home. Residency was measured based on the length of current home residency (calculated in months) and the daily average amount of time a child with ADHD spends within the home environment (calculated in hours). Indoor activity was measured as a percentage and included sleeping, sedentary activities, low-intensity activities, high-intensity activities, and other activities.

Territoriality, location, and proximity are other aspects of behavioural factors (Hassanain, 2008; Sanni-Anibire *et al*., 2016). They are included in the assessment tool as *outdoor environmental quality* and specifically comprise neighbourhood quality, location, green areas, and the outside view. We used eight variables for the measurement of outdoor environmental-related indicators, including the ratings of their suitability and checking for any relevant issues.

Symbolic factors are the aesthetic and thematic attributes of a building, and they are defined based on dwellers' artistic and design preferences (HPW, 2010). The assessment tool categorised them as *design factors* comprising furnishings, finishing materials, colour, and texture/pattern. We used 11 variables for the measurement of design-related indicators including the ratings of their suitability and the existence of any relevant issues. The predominant finishing material, colour, and texture/pattern of the home floor and interior walls were also included in the measurement.

Economic factors are classified as *socioeconomic factors* and contain housing tenure, household income, household expenses, energy use, employment status, and education level. The tool's *demographic factors* comprise gender, age, and marital status. Finally, the *overall quality of the housing environment* is included in the design of the questions. We used three variables for the measurement of the overall quality of the housing environment: 1) the overall suitability of home environmental quality, 2) the Net Promoter Score (NPS) of respondents as detractors, passives, or promoters of their overall home suitability, and 3) the overall score of home environmental quality. The first two variables were evaluated based on respondents' answers to two relevant rating-type questions, and the third variable was ascertained based on the average score for each respondent obtained based on their answers to the Likert-scale questions in the survey.

Table 2 presents the indicators and assessment criteria of the Housing Environmental Quality Assessment Tool (HEQAT).

Table 2. Indicators and assessment criteria of the Housing Environmental Quality Assessment Tool

Housing Assessment Criteria	Indicators
Demographic Factors	•Gender •Age •Marital status
Socioeconomic Factors	•Housing tenure •Household income •Household expenses •Energy use •Employment status •Education level
Spatial Factors	•Housing type •Access type •Size •Privacy
Indoor Environmental Quality	•Acoustic quality •Air quality •Thermal comfort •Lighting quality
Technical Factors	•Safety and security •Interior condition & maintenance •Structure and layout •Cleanliness
Behavioural Factors	•Crowding •Residency •Indoor activity
Design Factors	•Furnishings •Finishing materials •Colour •Texture/pattern
Outdoor Environmental Quality	•Neighbourhood quality •Location •Green area •Outside view
Overall Quality of Housing Environment	•Overall suitability of home environmental quality •Net Promoter Scores of detractors, passives, or promoters of home overall suitability •Overall score of home environmental quality

Survey description

The survey, structured as a self-administered questionnaire for the parents or guardians of children with ADHD, aimed to gather information on various aspects of the child's environment and demographics. It includes:

- Child's Background (4 questions): covers the child's ADHD diagnosis, symptom severity, age, and gender;
- Home and Neighbourhood Environment (63 questions): collects data on physical conditions, environmental quality, and participant perceptions; and
- Socio-demographics (7 questions): gathers background data on participants to contextualise findings.

The survey combines objective and subjective question formats, including multiple-choice questions, Likert scales, and open-ended responses. Participants can skip any questions, ensuring comfort in sharing personal information.

The tool is useful for researchers, housing professionals, and policymakers in identifying key indicators for ADHD-friendly environments and assisting families of children with ADHD in advocating for better housing quality. While the survey itself may not lead to immediate significant impacts, its application in a health context could be quite influential.

For instance, if the survey reveals issues such as inadequate space, poor ventilation, or lack of thermal comfort, it can support families to address these concerns as part of their comprehensive health care. This information can also be valuable when families are making decisions about accommodation, whether renting, buying, or building a home. When limitations exist within the home environment, recommendations can guide families to utilise outdoor parks or other facilities to provide suitable opportunities for children with ADHD.

The Delphi process

An establishment of content validity for the draft assessment tool was required to assure the reliability of the results. Therefore, the Delphi process was utilised to enable a modified focus group of experts to review the new assessment tool and to establish its potential usability and content validity.

Delphi is an iterative multistage process and a group facilitation technique. It seeks to collect anonymous feedback from a group of experts (known as a panel) on a particular topic and merge opinions into a group consensus, which is done through a series of structured surveys, known as rounds or cycles (Lynn *et al*., 1998; McKenna, 1994).

This methodology is appropriate for meeting the study aim, because the Delphi process is a flexible approach that is widely accepted and used for validating developed questionnaires and assessment tools (Clemson *et al*., 1999; Mengual-Andrés *et al*., 2016). Also, this method involves discussion and examination of a specific topic in depth through the communication process of an expert team (Geisser *et al*., 2011).

Panel recruitment

In this study, we aimed for a purposive sample of experts and stakeholders with balance across expert types. The expert team was purposefully selected to include those with relevant experience and expertise in the field of either ADHD or the built environment. Specifically, the inclusion criteria for expert panel membership included those with either academic, industry, or clinical expertise/background in the field(s) of building and/or ADHD. For the selection of stakeholders, parents of children with ADHD were included.

Twenty-three professionals and direct users were invited to participate in this research study to review the draft Housing Environmental Quality Assessment Tool. Twelve experts and stakeholders (in the aspects of the built environment and ADHD with an equal number in each group) registered as the panel to participate in the Delphi process. Specifically, the expert team consisted of three professionals with academic experience in the built environment, three professionals with clinical expertise around an ADHD diagnosis (psychologist/psychiatrist/mental health therapist with experience in children's treatment), three professionals with industry experience in construction and aspects of housing quality, and three stakeholders around ADHD with personal experience (parents of children with ADHD).

Data collection and expert review process

We performed the Delphi process in two rounds and collected data by administering two sets of anonymous online questionnaires designed on Qualtrics (an online survey design platform). The first round was run from June to July 2020, and the draft tool was reviewed by the experts and stakeholders (the panel in this study) and modified accordingly. The second round was run from August to September 2020 and resulted in the tool validation and development of the Housing Environmental Quality Assessment Tool (Appendix A). Figure 1 describes the flowchart of the Delphi process and how an individual participant progressed through the phases of the study process.

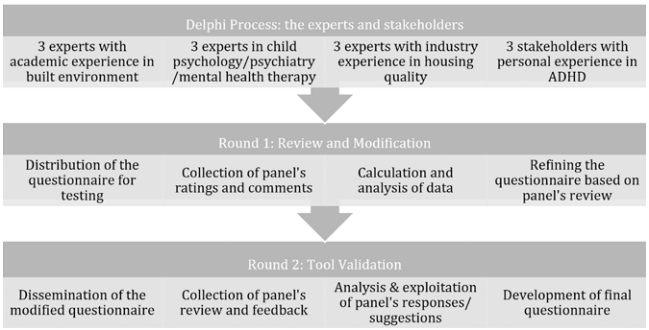

Figure 1. Flowchart of the Delphi Process (Source: Authors, 2024)

DATA ANALYSES AND RESULTS

Round 1: A review of the panel and feedback process

The draft Housing Environmental Quality Assessment Tool with 69 original items was reviewed and judged by the panel to address the following criteria through the Delphi process:

- Relevancy: to test if the questions are appropriate and relevant to the survey;
- Completeness: to minimise the repetitive questions and assure the conciseness of the survey; and

- Clarity: to simplify the contents and make the context understandable in everyday language and wording.

In the first round, the panel were asked to examine each tool item for relevance, domain coverage, completeness, and clarity on a three-point Likert scale of *yes*, *not sure*, and *no*. Furthermore, open-ended questions were used for each item of the tool, asking the participants to comment on aspects that, in their opinion, were not relevant, complete or clear, or were missing. An opportunity for additional notes was also given.

Analysis of the panel's review and measuring consensus

For data analysis, descriptive statistics were used to provide the frequencies of responses for each question. A content validity index (CVI) proposed by Waltz and Bausell (1981) was also used to establish the percentage of agreement. This method seeks to ascertain how much consensus among the panel specifies item acceptance or deletion by calculating the ratio of items decided to be content valid by experts through ratings.

We chose this method of data analysis because it provides an instructive and purposeful process for interpreting reviewers' judgments (Imle and Atwood, 1988). Other researchers have also suggested this method (e.g., Babbie, 1992). In this method, each item was assessed for problems in meaning, wording, relevance, or redundancy based on analysis of the reviewers' responses. This method was used to establish content validity (e.g., Tilden *et al*., 1990).

Analysis of the data from round 1 showed that the feedback and ratings were aggregated into three levels:

- Level 1 aggregates the panel's feedback for items with 80% and above agreement. There was majority agreement (80% and above) among panel members for the validity of 51 items out of the original draft survey that had 69 items in total. Therefore, it was assumed that these items were fundamentally valid and remained unchanged. Still, some items were refined based on the panel's remarks and entered into round 2 for the panel's review and degree of congruence;
- Level 2 aggregates the panel's feedback for items with 80% to 70% agreement. There was 80% to 70% congruence among panel members for the validity of 14 items out of the original draft survey with 69 items. Therefore, these items were changed and modified based on the feedback received and included in round 2 for the panel's review and degree of congruence; and
- Level 3 aggregates the panel's feedback for items with 70% and below agreement. There was less agreement (70% and below) among panel members on the validity of 4 items out of the original draft survey that had 69 items in total. Therefore, these items were removed from the tool. The decision to eliminate these items was reported in the second round, and an opportunity was provided for comment.

Table 4 summarises the quantification of the panel's comments from the first round of the Delphi process.

Table 4. Round 1: the Content Validity Index of the Housing EQ Assessment Tool (HEQAT)

Content Validity Index (CVI)	No. of Items
51 items=> Accepted as valid: remained unchanged (Congruence of 80% and above)	
1.00	11
0.92	5
0.91	8
0.90	4
0.83	6
0.82	13
0.80	4
14 items=> Questionable: changed and modified (Congruence of between 80% to 70%)	
0.78	1
0.75	6
0.73	7
4 items=> Invalid: eliminated (Congruence of 70% and below)	
0.70	1
0.64	2
0.58	1

Round 2: Refining and validation of the assessment tool

The data and feedback from the first round formed a report to run the second round of Delphi. All comments were listed in the report, and the modified or changed items (according to the panel's feedback in round 1) were explained. Unchanged and eliminated questions were also mentioned in the report. Furthermore, 11 new questions were added based on the panel's recommendations.

During the second round of Delphi, the panel were asked to rate their agreement with each of the changed, modified, and added items on a three-point Likert scale of *yes*, *not sure*, and *no*. Furthermore, open-ended questions were used for each item of the tool, asking the panel to comment if they did not agree with the change or any other aspects that, in their opinion, were missing, incomplete, or unclear. An opportunity for additional feedback was also given.

The panel reviewed and judged the second draft of the Housing Environmental Quality Assessment Tool with 76 items. Analysis of the data from round 2 showed that the feedback and ratings were aggregated into three levels:

- Level 1 aggregates the panel's feedback for items with 80% and above agreement. There was a majority agreement (80% and above) among panel members for the validity of 12 items out of 14 items that were changed or modified after round 1. Also, 7 out of 11 new

items were rated valid by panel members (with 80% and above agreement), which increased the number of valid items to 19 after round 2. Therefore, 70 items (51+19) were rated with a validity of 80% and above after two rounds of review;

- Level 2 aggregates the panel's feedback for items with 80% to 70% agreement. There was 80% to 70% congruence among panel members for the validity of 2 items out of 14 items that were changed or modified after round 1. Also, 2 out of 11 new items were rated with 80% to 70% validity. Therefore, 4 items were rated with a validity of 80% to 70% after two rounds of review. These four items were modified slightly according to the panel's comments in the second round; and
- Level 3 aggregates the panel's feedback for items with 70% and below agreement. There was less agreement (70% and below) among panel members on the validity of 2 new items (out of 11 new items) that were added to the tool after the first round. Therefore, these items were removed from the tool.

Table 5 summarises the quantification of the panel's responses from the second round of the Delphi process.

Table 5. Round 2: the Content Validity Index of the Housing EQ Assessment Tool (HEQAT)

Content Validity Index (CVI)	No. of Items (n=76)
70 items=> Accepted as valid: remained unchanged (Congruence of 80% and above)	
1.00	20
0.92	5
0.91	8
0.90	8
0.89	3
0.83	6
0.82	11
0.80	9
4 items=> Questionable: refined and modified (Congruence of between 80% to 70%)	
0.78	4
2 items=> Invalid: eliminated (Congruence of 70% and below)	
0.50	1
0.40	1

Determining the tool's overall content validity and reliability

After the second round of Delphi, final refinements and modifications were made based on the panel's feedback. All the items with validation of more than 70% were included in the final version of the tool, and the final validated tool with 74 items was developed.

The content validity index (Waltz and Bausell, 1981) was used to specify the overall content validity of the assessment tool. This was calculated by eliminating the deleted items from the final analysis of the panel's answers and remarks. Of the 74 items reviewed and rated by the panel over a 2-round Delphi process, a total of 70 items were judged to be valid with a CVI of more than 0.78. Of the 74 items, 4 items were rated with a content validity of 0.78. No items attained less than 78% agreement on validity. As a result, the tool's overall content validity was calculated as 95% (CVI = 70/74 ≈ 0.95).

The tool was used in a study conducted by Alizadeh *et al*. (2023) on a sample of parents, legal guardians, and carers of children and adolescents (5–17 years of age) with ADHD residing in Australia.

The tool was found to have excellent reliability (α = .93), as evidenced by Cronbach's Alpha, and validity (*ps < .924, r > .284*) as measured by bivariate correlations that demonstrated significant correlation between all items with their applicable factors and subfactors. Also, internal consistency was shown as all factor scores significantly correlated with the total score. Figure 2 illustrates the flowchart of the study's methodological process.

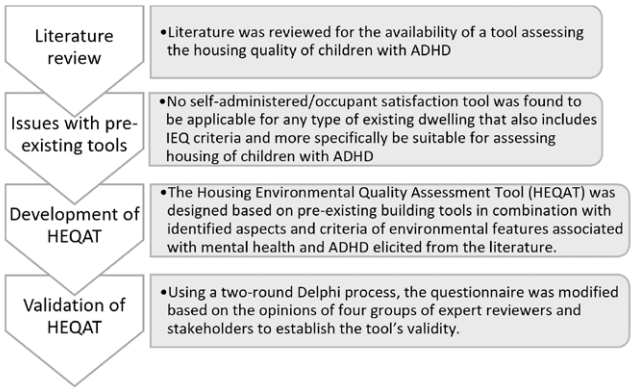

Figure 2. Flowchart of the study's methodological process (Source: Authors, 2024)

DISCUSSION AND CONCLUSION

Given the lack of an assessment tool that exclusively focuses on the intersection between housing environmental quality and ADHD, this tool was deemed critical due to the significance of the housing environment on residents' health. This study not only provides insight into the importance of housing quality for children's mental wellbeing, but also fills the gap in which there has been no focused assessment tool to evaluate the housing quality of those diagnosed with ADHD.

We believe that this assessment tool will be useful in identifying housing factors that may influence the symptoms and behaviours of children with ADHD, thus assisting in the development of solutions for improving their housing environmental quality. Improving the overall housing suitability and environmental quality could help improve physical comfort and quality of life for children with ADHD and their parents. This study represents a first step in building awareness among clinical experts and consumers

about the potential role of housing quality in mediating the clinical features and outcomes in ADHD. It also bridges the gap in building recognition among architects, designers, and developers about housing features that might adversely impact ADHD, leading to housing being made more suitable for children with ADHD.

The tool was validated using the Delphi process and the panel's reviews. The high level of consensus among the panel supported the HEQAT with a high content validity of 95 per cent. A set of assessment criteria for housing quality was generated and validated by employing logical and scientifically recognised processes in developing content validity. These assessment criteria can be beneficial in supporting a standard for other assessment tools and reproductions. Moreover, this procedure may serve as an application or a model for developing and validating future criterion-referenced assessment tools in building quality and mental health.

Some factors that may have contributed to the limitation of the study findings include sample selection. Although the Delphi process is popular and widely accepted within the academic community, it is not a well-known approach among clinicians, and hence participation may have been biased. While we acknowledge that there may have been selection bias in terms of representativeness, we are confident that the panel members as a group had a breadth of experience and skill sets that would have allowed diverse expertise and consumer/stakeholder opinions and views. Additionally, the exclusive use of a web survey for the Delphi process limited the interactive procedure and direct discussion among the panel members. While this was not feasible due to Covid-19 restrictions, we believe that there may have been advantages to the online process in allowing participation by clinicians who have limited time available and enabling group decision-making to be an iterative process without the pressure of conformity and dominant personalities.

It is expected that further use of the tool in future studies will help to ascertain its validity in different clinical conditions and settings, as well as further evaluation to improve and confirm the tool's reliability. We also recommend that future research should undertake further characterisation of the psychometric properties and examine its feasibility, acceptance, and suitability in various contexts.

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