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Health benefits of beaches

Testing of the BlueHealth Environmental Assessment Tool for the Australian context

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Research Summary

Why was the research done?

Beaches can be important health promoting settings. However, the quality of beaches may differ across neighbourhoods, and by neighbourhood socioeconomic. This may mean that not everyone has equal access to potential health and wellbeing benefits beaches can provide. More robust measurement of beach quality and the relationship with physical activity could provide information around what features are health and wellbeing promoting. This study modified and evaluated the reliability of the UK Blue Health Environmental Assessment Tool (BEAT) in an Australian context. The BEAT tool assesses the health enhancing features and activities taking place in blue spaces.

What were the key findings?

Australian beaches could be important settings for health promotion, due to the physical activity people do in and around these spaces. Overall, a modified version of the UK-based BEAT provided reliable measures of the attributes of beaches in an Australian context. Further research using the modified BEAT is needed to examine the relationship between attributes of beaches, socioeconomic status and health, to inform recommendations on how to protect and potentially improve modifiable attributes of these spaces.

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Abstract

Beaches can be important health promoting settings. However, the quality of beaches may differ across neighbourhoods. More robust measurement of beach quality and the relationship with physical activity could provide information around what features are health and wellbeing promoting. This study modified and evaluated the reliability of the UK Blue Health Environmental Assessment Tool (BEAT) in an Australian context. The BEAT tool assesses the health enhancing features and activities taking place in blue spaces.

Two trained assessors conducted audits of 10 beaches in Perth, Western Australia using a modified version of the BEAT tool. Beaches based in high and low socio-economic areas were selected. The BEAT tool was used to assess attributes of the social domain (use of the beach, user characteristics, safety and security), aesthetic domain (visual quality of the beach), and the physical domain (access and circulation, accessibility, built environment structures). Inter-rater and intra-rater reliability were assessed using intra-class correlation coefficients (ICCs).

Intra-rater and inter-rater reliability for the social domain (safety and security, site users and activities at site) ranged from good to excellent (ICC 0.60–1.00). ICCs for the aesthetic domain (visual quality of the site) were varied and ranged from poor-excellent (ICC=0.28-1.00). ICCs for the physical domain (access and circulation, accessibility and built environment structures) were mostly excellent (ICC=0.75-1.00) except for boat ramps (ICC=0.20) and physical disabilities access (ICC=0.57).

Overall, a modified version of the UK-based BEAT provided reliable measures of the attributes of beaches in an Australian context. Further research using the modified BEAT is needed to examine the relationship between attributes of beaches and health, to inform recommendations on how to protect and potentially improve modifiable attributes of these spaces.

Introduction

The natural environment such as green and blue spaces have the capacity to affect health and behaviour through providing aesthetic spaces for socialisation, restoration and physical activity. Few studies have investigated the relationship between the quality of natural blue spaces (e.g., amenities, biodiversity, safety) and health, however it is hypothesised higher quality natural spaces support greater health benefits for adults and children (Hunter et al. 2023; Smith et al. 2017).

Most measures of the natural environment assess attributes of green spaces, with the aim to impact green space design, management, general use and physical activity. Many green and blue spaces are collocated. Whilst many of these tools have a component assessing the water features within green spaces (Joseph and Maddock 2016; Badland et al., 2015), specific blue space environmental instruments assessing features which impact human health are only just emerging (Mishra et al. 2021). The Perceived Environmental Aesthetic Qualities Scale (PEAQS) is a validated self-report tool for the evaluation of green-blue spaces which measures the perceived quality of these spaces over five domains (i.e., Harmony, Mystery, Multisensory and Nature, Visual Spaciousness & Visual Diversity, Sublimity) (Subiza-Pérez et al. 2019). While the PEAQS is a structured tool that comprehensively assesses users aesthetic preferences of blue and green space, aspects of the built environment which could improve access to and use of these spaces (e.g., footpaths, safety, aesthetics, accessibility) are not assessed (Akpınar 2016; Feng and Astell-Burt 2017; Hillsdon et al. 2006).

An audit tool that does assess these components is the BlueHealth Environmental Assessment Tool (BEAT) (Mishra et al. 2021). To our knowledge the BEAT is the only validated tool designed specifically to assess features, amenities and factors that could maximise the health benefits of blue spaces. The BEAT was developed with the 'Person-Environment interaction' model in mind, establishing a link between the physical features of blue spaces and health and wellbeing (Mishra et al. 2021). It comprises an aesthetic (e.g., visual attractiveness of the area), physical (e.g., design, maintenance, and usability) and social (i.e., site users, type of activity at site, safety and security) domain with each feature scored on a scale from no to excellent provision. Activities taking place at the time of the visit, on land or in the water, are also recorded on a scale of being not to most present, as well as the assumed age, gender and number of people located at the site (Mishra et al. 2021). The BEAT protocol includes the option of qualitative comments and photographs to supplement scores.

The BEAT demonstrates high inter-rater reliability based on assessor training in European blue spaces (Mishra et al. 2021). It has been shown to be effective in revealing differences and similarities between various blue spaces, ensuring it accurately assesses factors that influence health and well-being (Mishra et al. 2021) in the European and UK context. To date this tool has not been used in countries based in the Oceania region, such as Australia. The applicability and health related outcomes may vary in the Australian context due to potential differences in the environment (warm climate), as well as cultural factors (beach and surfing culture) (Manero et al., 2024). Robust assessment of these environments is important for determining influences on children and adults' physical activity. Given the unique context, the purpose of this study was to examine if the BEAT tool could be modified for the Australian context, and if it retained intra and inter-rater reliability.

Materials and methods

Instrument modification

The BEAT tool was pilot tested for appropriateness in June 2023. Initial pilot data found several domains and attributes were not relevant in an Australian context and several needed modifications. Furthermore, the time to audit a beach took up to three to four hours in some instances. Thus, the BEAT tool was modified for the Australian context (see Supplementary Table 1 for full details). Nine attributes were modified (e.g., 'watch tower' changed to 'Lifeguard, Lifesaving and Safety Equipment') and four attributes were added (e.g., surfing, male children under five, female children under five, greenspace quality). Fifty-five attributes were removed as they were not relevant for the Australian beach context (e.g., snowboarding at the beach). The modified BEAT assessed the social domain (use of the site, site users, safety and security), the aesthetic domain (visual quality of the site), and the physical domain (access and circulation, accessibility, built environment structures). A second round of pilot data using the modified tool was collected in July 2023, to test for inter-rater and intra-rater reliability was tested.

Data collection

Data were collected across 10 beaches in Perth, Western Australia to assess intra- and inter-rater reliability. Beaches were purposely selected to be located in a mixture of low and high socioeconomic areas with a variety of attributes (Supplementary Table 2). Socioeconomic status (SES) of the neighbourhood the beach was located in was assigned using the Socio-Economic Indexes for Areas (SEIFA), 2021 Index of Relative Socio-economic Advantage and Disadvantage decile suburb ranking and characterised into high, middle and low SES (Australian Bureau of Statistics 2021). Deciles 1-5 were classified low SES, 6-8 were middle SES, and 9-10 were high SES. A 120-minute training session introduced the BEAT, provided examples and detailed the research protocol for conducting beach audits.

To assess the inter-rater reliability of the modified BEAT, each beach was visited at Time 1 by two auditors (rater 1 and rater 2). As per the original BEAT protocol qualitative comments and photographs were taken to supplement scores. Each visit took 30–90 minutes depending on the features of the beach. Beach visits were completed during October 2023 (spring). If it was forecast to rain, or the maximum temperature was less than 15 degrees Celsius or greater than 40 degrees Celsius, the weather was deemed not normal (by Australian standards), and the beach visit was rescheduled. Beaches were visited on Monday and Fridays, from 6am-2pm. These days and times were selected to best represent regular beach users and activities. To assess intra-rater reliability, rater 1 assessed all 10 beaches at a second time point within two weeks of the first visit (Time 2).

For the two beaches where more than 1000 people were present during the audit, a section of the beach was audited, and a comment added detailing the high number of people at the beach. These beaches were not included in the inter-reliability ICC for the *site users* attribute.

Statistical analysis:

All data analysis was conducted in R (version 4.4) 2023 (R Core Team 2023). Descriptive statistics were calculated using base functions in R and inter-rater and intra-rater Intraclass Correlation Coefficient (ICC: an absolute agreement type, one-way mixed effect model) were calculated using the lme4 package (Bates et al. 2015). ICC scores of < 0.40 were classified as poor, 0.40 to 0.59 classified as fair, 0.60 to 0.74 classified as good, and 0.75 to 1.00 classified as excellent (Cicchetti 2017). Where there was no variability in ICC scores, the raw percentage agreement was calculated (e.g., 100%).

The attribute *total people* were calculated by adding all genders and age groups together. For the physical domain access and circulation and built environment structures, the visual appearance, functionality, and condition, scores were added together and averaged.

Results

Beach characteristics

Beaches were mostly open sandy beaches (n=7), and three were smaller sandy beaches which were enclosed by rocks or reef. Perth, Western Australia is a major city with the Swan River running through the middle of the city creating a north-south divide. Six beaches were located north of the river and four beaches were located south of the river. Three of the ten beaches were located in low SES neighbourhoods and five beaches were dog beaches (Supplementary Table 2). In Western Australia, dogs are generally only allowed on specific beaches. Seven beaches had adjacent green space, two beaches were next to oil refineries, one beach was next to a marina.

Intra-rater reliability of the modified BEAT

Intra-rater reliability ICCs for attributes of the aesthetic domain (visual quality of the site) varied and ranged from poor-excellent (ICC=0.28-1.00) (Table 1). Of these attributes *attractiveness of vegetation at the site*, *sense of wildness* and *quality of views* all had poor intra-rater reliability, with the other aesthetic domain attributes ranging from good to excellent.

The attributes of access and circulation on the physical domain were all excellent (ICC=0.83-0.97). Both accessibility and built environment structures (physical domain) were also consistently excellent (ICC=0.81-0.99; several 100% agreement).

The intra-rater reliability ICC for attributes of the social domain - safety and security were excellent (ICC = 0.80–1.00; several 100% agreement). For *the presence of threatening people* attribute, the intra-reliability score was unable to be estimated due to little or no variability.

Inter-rater reliability of the modified BEAT

Inter-rater reliability ICCs for attributes of the aesthetic domain (visual quality of the site) varied and ranged from poor-excellent (ICC=0.00-1.00) (Table 7-1). Of these attributes on the aesthetic domain attractiveness of vegetation at the site *attractiveness of vegetation at the site* scored poor, with the rest ranging from fair to excellent.

The attributes of the physical domain - access and circulation were all excellent (ICC=0.79-0.86), with *onsite car parking* scoring 100% agreement. The exception was *boat launching access and ramps*, which had poor inter-rater reliability (ICC=0.20). Both accessibility and built environment structures (physical domain) were also consistently excellent (ICC=0.89-0.99; several 100% agreement) except for the attribute *physical disabilities access* which had a fair inter-reliability ICC of 0.57.

The inter-rater reliability for attributes of the social domain - safety and security ranged from good to excellent (ICC = 0.61–1.00; 100% agreement). Site users and activities at the site ranged from poor to excellent (ICC=0.20-0.95; several 100% agreement). Of these attributes *cycling* scored poorly, with the other attributes scoring good to excellent. Inter-rater reliability of the *running* attribute was unable to be estimated due to little or no variability in the measures.

Table 1 Intra—and inter-rater reliability results for the modified BEAT environmental audit

Domain (n=3)	Blue space attribute (n=51)	Intra-rater reliability (n=10)			Inter-rater reliability (n=10)		
		Time 1 Mean (SD)	Time 2 Mean (SD)	ICC (95% CI)/ % agreement	Rater 1 Mean (SD)	Rater 2 Mean (SD)	ICC (95% CI)/ % agreement
Aesthetic domain- visual quality of the site	Quality of views within the site	2.0 (1.25)	2.2 (0.63)	0.37 (0.00-0.93)	2.0 (1.25)	1.9 (1.10)	0.96 (0.79-0.99)
	Quality of views to the site from the water	3.8 (0.63)	3.7 (0.68)	0.88 (0.30-0.97)	3.8 (0.63)	3.7 (1.42)	0.62 (0.03-0.90)
	Visual quality of built structures within the site	2.6 (1.5)	2.7 (1.06)	0.67 (0.07-0.91)	2.6 (1.50)	1.7 (1.42)	0.50 (0.01-0.87)
	Attractiveness of vegetation on the site	3.8 (0.62)	3.2 (0.92)	0.28 (0.01-0.81)	3.8 (0.62)	2.1 (0.88)	0.00
	Light pollution at night	2.5 (1.26)	3.0 (1.25)	0.79 (0.30-0.98)	2.5 (1.26)	2.0 (1.63)	0.61 (0.02-0.86)
	Sense of wildness	2.3 (1.06)	1.7 (0.67)	0.30 (0.00-0.79)	2.3 (1.06)	1.8 (1.22)	0.67 (0.06-0.90)
	Greenspace quality	2.9 (2.18)	3.4 (2.01)	0.81 (0.38-0.95)	2.9 (2.18)	2.1 (1.60)	0.84 (0.14-0.97)
Physical domain- access and circulation	Unpleasant smell	0.9 (1.66)	0.6 (1.58)	0.91 (0.56-0.97)	0.9 (1.66)	0.9 (1.63)	1.00 (1.00-1.00)
	Access roads average score ¹	2.6 (1.00)	2.4 (1.00)	0.83 (0.31-0.98)	2.6 (1.00)	2.2 (0.90)	0.79 (0.15-0.97)
	Onsite car parking average score ¹	2.2 (1.00)	2.3 (1.00)	0.86 (0.41-0.97)	2.2 (1.00)	2.2 (1.00)	100%
	Boat launching access and ramps average score ¹	0.6 (1.30)	0.5 (1.00)	0.96 (0.72-0.99)	0.6 (1.30)	0.2 (0.50)	0.20 (0.00-0.68)
	Footpath network average score ¹	2.8 (1.10)	3.2 (1.30)	0.90 (0.51-0.97)	2.8 (1.10)	2.8 (1.10)	0.86 (0.53-0.97)
	Cycle path network average score ¹	2.6 (1.10)	2.8 (1.60)	0.97 (0.41-0.97)	2.6 (1.10)	2.1 (1.10)	0.86 (0.29-0.99)
Physical domain- accessibility	Path construction and use of materials average score ¹	2.0 (0.80)	2.6 (1.20)	0.75 (0.05-0.98)	2.0 (0.80)	1.8 (0.60)	0.84 (0.23-0.98)
	Physical disabilities access	1.7 (0.80)	1.7 (1.10)	0.89 (0.49-0.96)	1.7 (0.80)	1.3 (1.10)	0.57 (0.04-0.89)
	Accessibility for blind and partially sighted	0.0 (0.00)	0.0 (0.00)	100%	0.0 (0.00)	0.0 (0.00)	100%
	Accessibility for deaf and hearing impaired	0.0 (0.00)	0.0 (0.00)	100%	0.0 (0.00)	0.0 (0.00)	100%
Physical domain- built environment structures	Accessibility for people with mental and learning disabilities	1.0 (0.00)	1.0 (0.00)	100%	1.0 (0.00)	1.0 (0.00)	100%
	Toilets average score ¹	1.9 (1.7)	1.9 (1.60)	1.00 (0.99-1.00)	1.9 (1.70)	1.7 (1.60)	0.96 (0.84-0.99)
	Changing rooms average score ¹	1.4 (1.90)	1.4 (1.90)	100%	1.4 (1.90)	1.2 (1.60)	0.95 (0.71-0.99)
	Café/ restaurant/ coffee van average score ¹	1.3 (2.10)	1.3 (2.10)	100%	1.3 (2.10)	1.2 (2.00)	0.97 (0.85-0.99)
	Art installation average score ¹	0.9 (1.10)	0.9 (1.10)	100%	0.9 (1.10)	0.8 (1.00)	0.98 (0.87-1.00)
	Playground average score ¹	1.9 (2.00)	1.5 (2.00)	0.81 (0.36-0.96)	1.9 (2.00)	1.1 (1.40)	0.78 (0.07-0.96)
	Lifeguard, Lifesaving, Safety equipment average score ¹	1.2 (1.90)	1.2 (1.90)	100%	1.2 (1.90)	1.2 (1.60)	0.91 (0.65-0.97)
	Observation deck average score ¹	0.3 (1.10)	0.4 (1.30)	0.98 (0.83-1.00)	0.3 (1.10)	0.3 (1.00)	0.99 (0.97-1.00)
Physical safety and security against traffic and along water edges	2.3 (1.64)	2.2 (1.55)	0.98 (0.81-1.00)	2.3 (1.64)	2.8 (0.79)	0.61 (0.01-0.94)	

Social domain- safety and security	Presence of water safety equipment and lifeguards	1.3 (1.77)	1.3 (1.77)	100%	1.3 (1.77)	1.3 (1.77)	0.97 (0.88-1.00)
	Presence and functionality of lighting	1.7 (1.16)	1.8 (1.14)	0.96 (0.82-1.00)	1.7 (1.16)	1.5 (0.85)	0.81 (0.46-0.98)
	Sense of general security against crime or anti-social behaviour	4.3 (1.06)	4.3 (1.06)	100%	4.3 (1.06)	4.6 (0.70)	0.69 (0.03-0.96)
	Presence of vandalism or damage signalling lack of security	0.7(1.25)	0.6 (1.26)	0.97 (0.71-0.99)	0.7(1.25)	0.4 (0.97)	0.88 (0.36-0.99)
	Presence of threatening people	0.1 (0.31)	0.0 (0.00)	**	0.1 (0.31)	0.1 (0.32)	100%
	Signs of alcohol or drug use	0.4 (0.52)	0.3 (0.48)	0.80 (0.42-0.97)	0.4 (0.52)	0.6 (0.97)	0.67 (0.17-0.88)
Social domain- Site users	Total people at the beach ^{2,3}	18.3 (9.0)	39.3 (33.11)	-	18.3 (9.0)	13.8 (8.83)	0.70 (0.10-0.95)
Social domain- activities at site	Walking	3.3 (1.57)	3.2 (0.4)	-	3.3 (1.57)	3.9 (1.52)	0.84 (0.48-0.97)
	Walking with a dog	3.3 (2.06)	3.2 (2.20)	-	3.3 (2.06)	3.0 (1.94)	0.91 (0.52-0.98)
	Running	0.7 (0.93)	0.4 (0.51)	-	0.7 (0.93)	0.2 (0.42)	**
	Cycling	0.9 (1.20)	1.1 (1.28)	-	0.9 (1.20)	0.6 (0.70)	0.20 (0.02-0.88)
	Informal games	0.7 (1.05)	0.5 (0.53)	-	0.7 (1.05)	0.5 (0.71)	0.75 (0.34-0.94)
	Fishing	0.3 (0.67)	0.4 (0.96)	-	0.3 (0.67)	0.3 (0.67)	100%
	Conservation activity	0.0 (0.00)	0.0 (0.00)	-	0.0 (0.00)	0.0 (0.00)	100%
	Sunbathing (sit or lie in the sun, with the purpose to tan the skin)	1.2 (1.47)	0.5 (0.85)	-	1.2 (1.47)	1.7 (2.06)	0.74 (0.23-0.95)
	Playing with children	1.1 (1.29)	1.0 (1.56)	-	1.1 (1.29)	0.9 (1.37)	0.94 (0.64-0.99)
	Appreciating scenery from a car	3.3 (1.70)	1.9 (1.80)	-	3.3 (1.70)	3.2 (1.69)	0.80 (0.32-0.96)
	Eating or drinking	1.2 (1.40)	1.4 (1.57)	-	1.2 (1.40)	1.2 (1.13)	0.81 (0.21-0.96)
	Socialising with friends	1.2(1.87)	1.6 (1.95)	-	1.2(1.87)	2.4 (1.95)	0.60 (0.05-0.91)
	Watching wildlife	0.0 (0.00)	0.5 (1.08)	-	0.0 (0.00)	0.0 (0.00)	100%
	Boating	0.3 (0.48)	0.7 (1.57)	-	0.3 (0.48)	0.3 (0.48)	100%
	Surfing	0.1 (0.31)	0.0 (0.00)	-	0.1 (0.31)	0.1 (0.31)	100%
Paddling/ surfski paddling/kayaking	0.3 (0.95)	0.0 (0.00)	-	0.3 (0.95)	0.3 (0.95)	100%	
Swimming	2.6 (2.31)	2.4 (1.96)	-	2.6 (2.31)	2.3 (2.21)	0.95 (0.66-0.99)	
Diving	0.1 (0.31)	0.0 (0.00)	-	0.1 (0.31)	0.1 (0.31)	100%	

Inter-rater and intra-rater ICC's were calculated using an absolute agreement type, one-way mixed effect model. ICC scores of < 0.40 were classified as poor, 0.40 to 0.59 classified as fair, 0.60 to 0.74 classified as good, and 0.75 to 1.00 classified as excellent. Where there was no variability in ICC scores, raw percentage agreement was calculated (e.g., 100%).

¹Average scores were calculated by adding the visual appearance, functionality, and condition scores together and then dividing by three.

²Total people is the sum of all site user categories at the beach

³Only 8 observations included

** variance unable to be calculated as too many 0's in dataset

-These items would be different across two time points and therefore only intra-rater reliability calculated

Discussion

Reliable measures of the quality of blue spaces such as beaches are needed to determine how people move in and around these spaces, and the associated health related benefits. This study evaluated the reliability of the modified BEAT, in Perth, Western Australian. The main modifications included changing the wording of items to align with the Australian beach context, adding Australian beach relevant items and combining or removing attributes to reduce the length of time taken to complete the audit. We found the modified BEAT audit had fair to excellent intra-rater reliability and good to excellent inter-rater reliability for all three domains (aesthetic, physical and social). Our findings are consistent with Mishra et al. who found the BEAT to be a reliable tool to assess blue spaces generally in the United Kingdom and Europe (Mishra et al. 2021).

However, several items scored poor inter-rater reliability, in particular *attractiveness of vegetation* and *boat launching access and ramps*. Whilst *attractiveness of vegetation* also scored poorly in the assessments in Europe and thus should be used with caution, *boat launching access and ramps* was reliable when previously assessed (Mishra et al. 2021). The poor inter-rater reliability of *Boat launching access and ramps is likely due to the very low prevalence of boat ramps as well as* rater misclassification error. It is likely the subjective nature of what is deemed 'attractive' vegetation contributed to the poor inter-rate reliability in the current and previous study. Pictorial descriptors and additional written descriptors (e.g., images of what is deemed attractive vegetation) could be a way to improve the reliability of this item (Maitland et al. 2020).

Similarly, three items scored poor for intra-rater reliability (*attractiveness of vegetation; quality of views within the site; sense of wildness*). Across two timepoints it is logical that attribute scores of *quality of views within the site* and *sense of wildness* can change. The *quality of views within the site* attribute measures the view whilst on the beach looking at the water. The *sense of wildness* attribute measures the view together with the site features conveying a sense of being in a natural or wild environment. These attributes scores could vary due to weather conditions on the day the audits are conducted (e.g., overcast day and prevailing winds vs. sunny and low winds), or presence of people at the beach (e.g., busy vs. quiet). Unlike the *attractiveness of vegetation* item, a similar item *greenspace quality* (i.e., shade from trees and artificial means, presence of grass, benches and barbeques facilities) had excellent inter-rater and intra-rater reliability. This is likely due to the attributes being easier to identify and score. Additionally given the warm climate, grass and shade may be particularly important in the local context (Ignatieva et al. 2024).

Several attributes were mostly either absent (e.g., accessibility) or consistently present (e.g., sense of security against crime) across all beaches. This was particularly relevant for the physical domain of accessibility, with most beaches not having features that were supportive of people experiencing hearing loss, vision impairment or intellectual/learning disability. Additional research using the modified BEAT is needed to examine the relationship between the attributes of beaches that are beneficial to all people's health, not just abled bodied people. Furthermore, features such as ramps and may benefit multiple groups within society such as caregivers with prams, people who use a wheelchair and older adults.

On busy beach days the *site users* attribute was not reliable. A high number of people (over 1000 people) on two of the beaches audited meant the count of people present was not possible. When these two beaches were removed from the analysis, the site users attribute scored well on inter-rater reliability. Future use of the BEAT on busy beach days could consider a statistical sampling approach (such as momentary time sampling to record observations to ensure the estimates are more reliable (McKenzie et al. 2006) .

Strengths and Limitations

Only ten beaches were audited as part of the reliability testing of this modified version of the BEAT. Despite this, the modified BEAT included three domains with a total of 51 attributes representing a comprehensive assessment of the attributes of blue spaces. Several beach attributes exhibited no variability, and although the percentage agreement was high, these items may not provide sufficient variation in the Australian context. Additionally, a high number of people on two of the beaches audited meant counting the number of people present was not possible. Future assessments should consider utilising a statistical sampling approach to ensure estimates of site users are reliable. While open-ended responses were included to provide greater clarity on what constituted a particular attribute and condition, pictorial descriptions could further strengthen the reliability of the BEAT, particularly for items which are more subjective in nature. Finally, further testing in rural and regional areas and other countries with differing physical, social and policy environments is recommended.

Conclusions

Beaches are important settings for health promotion, due to the physical activity people do in and around these spaces and the restorative benefits. Whilst some attributes should be interpreted with caution, the modified BEAT provides a reliable measure of the attributes of beaches in an Australian context. Further research using the modified BEAT is needed to examine the relationship between attributes of beaches and health, to inform recommendations on how to protect and potentially improve modifiable attributes of these spaces. Furthermore,

determining these features and influences is important to advance evidence-based planning and design of blue spaces to promote health and wellbeing.

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Supplementary Material

Supplementary file 1

Table 2 Summary of the modifications of the original BEAT

Blue space domain (n=3)	Original aspects (n=12)	Original blue space attributes (n=125)	Modification made to original (n=68)
Social	Activities at Site	Walking	
		Walking with a dog	
		Nordic walking	removed, not relevant in Australian context
		Running	
		Cycling	
		Horse riding	removed, two beaches in region horse exercise areas
		Golf	removed, not relevant in Australian context
		Adventure sport	removed, more specific sports added
		Informal games	
		Fishing	
		Hunting	removed, not relevant in Australian context
		Conservation activity	
		Sunbathing	
		Visiting an attraction	removed, not relevant in Australian context
		Quiet activities	removed, encompassed in sunbathing or appreciating scenery or watching wildlife
		Playing with children	
		Appreciating scenery from a car	
Eating or drinking			
Socialising with friends			
Watching wildlife			
Boating			
Commercial boat trip			
Paddling	removed, encompassed in boating modified wording to specify surf ski and kayaking		

Activities- indirect evidence	Swimming	removed, more specific sports added
	Watersport	edited protocol to encompass snorkling/ free diving
	Diving	removed, not relevant in Australian context
	Ice skating	removed, not relevant in Australian context
	Skiing	removed, not relevant in Australian context
	Sledding	removed, not relevant in Australian context
	Snow boarding	removed, not relevant in Australian context
	Snowmobiling	removed, not relevant in Australian context
	Snow biking/ snow drifting	removed, not relevant in Australian context
	Ice fishing	removed, not relevant in Australian context
	Ice swimming	removed, not relevant in Australian context
	Ice boating	removed, not relevant in Australian context
	Snow team sports	removed, not relevant in Australian context
	Surfing	Added in, common activity at Australian beaches
By or near water	Removed fully qualitative, direct evidence of activities captured	
Site users	On water	Removed fully qualitative, direct evidence of activities captured
	Winter activities	Removed fully qualitative, direct evidence of activities captured
	*Children under 5-male	Added in, age group of interest, furthermore as Monday and Friday visits 6am-2pm and outside of school holidays, most children at the beach during school hours 8-2pm will be under 5
	*Children under 5-female	Added in, age group of interest, furthermore as Monday and Friday visits 6am-2pm and outside of school holidays, most children at the beach during school hours 8-2pm will be under 6
	Children under 6-9-male	
	Children under 6-9-female	
	Adolescents (10 to 19 years)- male	
	Adolescents (10 to 19 years)- female	
	Young adults (20 to 39 years)- male	
	Young adults (20 to 39 years)-female	
	Mature adults (40 to 64 years)-male	
	Mature adults (40 to 64 years)-female	
	Older adults (65 years and above)-male	
	Older adults (65 years and above)-female	

Information and Education	Presence, and usefulness of information	removed, as some of these aspects covered in Accessibility section scores
	Presence and functionality of way marking or directional signs	removed, as some of these aspects covered in Accessibility section scores
	Presence and clarity of codes of conduct/rules and regulations	removed, as some of these aspects covered in Accessibility section scores
	Interpretive structures giving information of value to visitors of a cultural, historical or environmental nature	removed, as some of these aspects covered in Accessibility section scores
	Accessibility of information for people with different types of disability	removed, as some of these aspects covered in Accessibility section scores
	Presence of information in a range of languages	removed, as some of these aspects covered in Accessibility section scores
Safety and Security	Physical safety and security against traffic and along water edges	
	Presence of water safety equipment and lifeguards	Adjusted protocol to reflect local context, and be replicable 0= not present, 1= defib box/ shark alarm/ emergency phone 2= roving patrol (lifeguard on adjacent beach that drives/ walks down intermittently) 3=patrolled lifesavers weekends only or in season (presence of surfclub), 4= Professional lifeguards during week in season (these vary council to council but are approximately Oct-May) 5=year round lifeguard or lifesaving presence
	Presence and functionality of lighting	
	Sense of general security against crime or anti-social behaviour	
Anti-social activity	Absence of vandalism and lack of safety	Modified to presence of threatening people
	Absence of threatening people	Modified to presence of alcohol or drug use (including cigarettes and vapes)
	Absence of alcohol and narcotic Activities	Removed fully qualitative and should be covered in safety and security score
Aesthetic	Identify anti-social activities that are taking place within the site (direct or indirect evidence)	
	Visual Condition	removed, replication with quality below
	Visual quality of buildings and other structures visible along the site boundaries	removed, replication with quality below
	Screening of eyesores by trees and vegetation	removed, replication with quality below
	Quality of views out from the site across the water	removed, replication with quality below
Sense of openness and scale of water views	removed, replication with quality below	
Presence of focal points visible from the site	removed, replication with quality below	

	Visual Quality	Absence of visual pollution Quality of views within the site	removed, replication with quality below
		Quality of views to the site from the water Visual quality of built structures within the site Attractiveness of vegetation on the site Absence of light pollution Sense of wildness *Greenspace quality	Added to incorporate more manicured adjacent greenspaces with natural shade from trees or artificial shade gazebo's, shade sails, public BBQ's water fountains, playgrounds
	Non-Visual Aesthetics	Pleasant smells within the site	changed to unpleasant smells at site and incorporated in section above
		Absence of unpleasant smell Pleasant sounds within the site	removed replication with quality above removed, subjective and although evidence on sounds in blue spaces for health and wellbeing clear guidance on what could be pleasant is missing
		Absence of noise pollution Sense of atmosphere: wind, moist air etc. Feeling of tranquillity or calm	removed replication with quality above removed, captured in sense of wildness removed capture in sense of wildness
Physical	Access and Circulation (Condition, visual appearance and functionality score)	Access roads within the site	
	Disabled Access	Car parking onsite Boat launching access and ramps Footpath network Cycle path network Path construction and use of materials Physical disabilities access	
		Accessibility for blind and partially sighted Accessibility for deaf and hearing impaired Accessibility for people with mental and learning disabilities	

Terrestrial
Recreation
Structure
(Condition,
visual
appearance
and
functionality
score)

Toilets

Changing rooms
Changing cubicles
Cafe/restaurant

Combined with cubicles
removed, combined with section above
modified to include coffee vans which are common at
Australian beach car parks

Fountain
Art installation
Children's play area
Safety equipment store
Watch tower
Observation deck
Food and ice cream stall

changed wording to playground

changed wording to Lifeguard, Lifesaving, Safety equipment

This is less common in Australia and should be encompassed
in café/ restaurant/ coffee van

Water
Recreation
Structure
(Condition,
visual
appearance
and
functionality
score)

Sauna
Boat slipway

removed, no relevant in

Jetty
Pier
Dock edges
Marina
Harbour wall
Bridge
Locks
Paddling pool
Swimming pool

removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context
removed, not relevant/ common in Australian context

Site
Management

Maintenance of hard surfaces

removed, should be covered in condition scores, and reflected in average scores

Management of vegetation

removed, should be covered in condition scores, and reflected in average scores

Maintenance of street furniture

removed, should be covered in condition scores, and reflected in average scores

Site maintenance in general

removed, should be covered in condition scores, and reflected in average scores

Maintenance of play areas

removed, should be covered in condition scores, and reflected in average scores

Maintenance of safety equipment

removed, should be covered in condition scores, and reflected in average scores

* indicates items added

Supplementary file 2

Table 3 Location and characteristics of beaches audited.

Beach name	Environment type	Neighbourhood characteristics
Rockingham Dog Beach	Adjacent greenspace, dog beach, sandy open beach	South of the River, Low SES
Kwinana Beach	Adjacent greenspace, sandy open beach, next to a refinery	South of the River, Low SES
Challenger Beach	Small sandy beach, next to a refinery	South of the River, Low SES
South Beach Dog Beach	Adjacent greenspace, sandy open beach with groynes, next to marina, dog beach	South of the River, High SES
South City Beach Dog Beach	Sandy open beach, roving patrol	North of the River, High SES
City Beach	Adjacent greenspace, sandy open beach with groynes, patrolled beach	North of the River, High SES
Floreat Beach	Adjacent greenspace, sandy open beach with groynes, patrolled beach	North of the River, High SES
Peasholm Dog Beach	Adjacent greenspace, sandy open beach, dog beach	North of the River, High SES
Ada Street Dog Beach	Small sandy beach, dog beach	North of the River, High SES
Watermans Bay	Adjacent greenspace, large sandy beach	North of the River, High SES