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iMOVE 6-002
Australian Size Variation for Design

M002 D1&2: Interviews, NHS data scoping

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Developed by the Alliance for Research in Exercise, Nutrition and Activity (ARENA), Allied Health and Human Performance (AHHP); and the Studio for Human Complex Environment Design (SCHED), Australian Centre for Interactive and Virtual Environments (IVE), University of South Australia.

François Fraysse *PhD*, University of South Australia

Peter Schumacher *PhD,* University of South Australia

Alistair Furnell *PhD*, Department of Transport Victoria

Christina Kirsch *PhD*, Transport for NSW

Paul Murray *PhD*, Australasian Centre for Rail Innovation

Contact information

Dr Francois Fraysse

✉ Alliance for Research in Exercise, Nutrition and Activity (ARENA)
Allied Health and Human Performance (AHHP)
University of South Australia
P7-07, City East Campus
GPO Box 2471
Adelaide SA 5001

+61 8 8302 2139
francois.fraysse@unisa.edu.au

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Executive Summary

This report presents the outcomes of Phases 1 and 2 of iMOVE Project 6-002, “Australian Size Variation for Design”.

In **Phase 1**, we conducted interviews with key personnel in the Human Factors area of the Australian Transport Industry. The goal was to identify current approaches employed by designers and end users to assess space requirements and population accommodation in the Australian Transport industry.

The range of applications of Human factors in the industry is extremely broad. For most key personnel, space requirements and anthropometry considerations are only a small fraction of their roles. These users are not expert in space requirements analysis; most commonly they use basic anthropometry data (often obtained through the software PeopleSize) to perform rapid checks. The level of confidence in the available data is low. Physical prototypes are rarely used.

In **Phase 2** we conducted a scoping of available Australian anthropometric data. We targeted publicly funded research projects (NHMRC), the AADBase dataset, the Sizing Up Australia project, and the National Health Surveys. The purpose of this phase was to collate all currently available datasets applicable to the Australian Transport Industry.

We identified the NHS 2014 and 2017 datasets as the most complete, and containing the largest sample sizes by a significant margin. We obtained access to the NHS datasets from the Australian Bureau of Statistics (ABS), processed the data and prepared it for released, which we obtained from the ABS.

We present summary results for Australian body sizes, by age group and sex. We also compare the values to data available in commonly-used software PeopleSize. We identify two main issues with the PeopleSize Australian data: the absence of children data, and an underestimation of extreme body sizes for adults.

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End-users interviews

Introduction

Project members identified key personnel of various companies and government bodies, working in the Human Factors area within the Australian Transport Industry. We (PS) conducted one-on-one phone interviews with these key personnel in April and May 2022 until reaching data saturation. We interviewed 10 people in total.

The key elements we aimed to elucidate were:

- Are anthropometric and space requirements considerations currently used in the Australian Transport Industry, and if so, in which manner and at what stage. Space requirements can be used toward the beginning of the design stages, in order to provide an initial de-risking of the designs; or they can be used after the design phase to provide a form of quality assurance. Methods can differ depending on the intended use.

- If anthropometric data is currently used: which dataset(s) are being used, and in which manner? For instance, tables of reference anthropometric dimensions; or minimum space requirements; or digital models at the conception stage. This will help identify the preferred way of integrating anthropometric requirements into the workflow.

Interviews were conducted in an open manner. However, **twelve main themes** were used to guide the conversation and were discussed during each interview:

1. What are your role and responsibilities?
2. Which anthropometry data bases do you use, if any?
3. What level of confidence do you have in the data?
4. Do you use any Australian standards relevant to human factors or anthropometry?
5. Which anthropometry percentile ranges do you typically use for accommodation targets?
6. Do you consider other factors such as clothing and other clearances?
7. Do you use Digital Human Models (DHM) or other 3D tools?
8. Are you aware of any in-house anthropometric measurements made?
9. Do you use physical models during the design process?
10. If you do trials of physical models, how do you select participants?
11. What processes do you typically us?
12. Do you have recommendations for future development of Human Factors?

Appendix 2 provides the full interview notes for each question and interviewee. In this section, we present a summary of the responses to each main theme.

Role and responsibilities

Many of the people interviews fell broadly into 2 categories: people with psychology backgrounds, and those with technical/engineering backgrounds.

The Psychology group were comfortable with statistics, however did not have computer CAD or DHM skills for 3D analysis. As a general observation, the psychology group were not using anthropometry a as a core part of their work, but as a small component of a wider range of Human Factors responsibilities and may only use anthropometry 2-3 times a year. They would be more likely to be involved in evaluating work done by consultancies or engineers in their group.

The engineers were more able to use 3D CAD and DHM tools. They were more likely to be involved with the physical design. In government, they acted as “consultants” to the engineers working on a variety of projects.

Interviewers access anthropometry databases to address particular issues and situations:

The designers working in automotive did not need to access the anthropometry, as this was managed by a core group that interpreted the automotive standards and consolidated the anthropometry data to accommodate international users and the knowledge base of the organisation. This was possible because this was a large multinational company, with the resources to develop internal standards and also to ensure a consistent approach. Also this was for the automotive industry that is constrained by standards, and has relatively well defined and constrained use scenarios.

Other organisations did not have the scale or need for an internal group to create standards for the organisation. As a result, they were required to develop their own investigation and interpretation of the data on a case by case basis.

Anthropometry data bases in use

Most people reported using the PeopleSize software. Of those that did not use it, they either wanted access or could get access through partners. The automotive interior designer did not need access as this was accessed by the core team tasked with developing internal standards.

Many people use the 2008 version, some are using 2020 which is the latest release. Some mentioned they wanted to update but did not think the updates to the data in 2020 warranted upgrading.

PeopleSize is liked because people are familiar with it, it has a good user interface, it is perceived as being an industry standard. It includes a range of poses that can be selected that best represent the use case scenario.

The usability of PeopleSize was one of the main reasons people preferred it. Other sources such as Pheasant and Humanscale were mentioned for the same reason. WEAR was mentioned by a few and it was not used much because of its difficult of access.

This is in our opinion a critical outcome of these interviews: no matter how good the data is, ease of use is a very high priority. Many of the people do not frequently access the data (maybe 2-3 times a year) so a difficult to learn and complex interface, even if more technically precise, will not be of great value or use.

Some software have access to different databases, such as US military data. The WEAR software uses Ceasar. Pheasant and Humanscale use "Body Space" and the UK department of transport and industry 1990, automotive industry standards SAE J826.

Queensland rail conducted an anthropometric survey of 150 people 10 years ago that was mainly males with some females. Following the measurement guidelines from the ISO, this focused on traffic crews.

Confidence level in anthropometric data

All interviewees understood that the data sources are out of date and do not reflect the general population of Australia or the specific user groups, particularly train drivers and rail workers that are skewed to older, larger males.

Ethnic differences in populations also need to be considered, as Australia is ethnically diverse and there are different ethnic profiles in different areas, with different body sizes and shapes.

Overall, the data is understood to be a 'rough and ready' approximation, and is not interpreted or relied on as an accurate representation of the Australian population. Credibility and validity of the data are crucial questions.

People are often asked to address ergonomic problems in short time frames and do not have the luxury of time to do a broad anthropometric database search and comparison. So whatever is available and easy to access is the best tool, despite the understanding that it is not necessarily representative of the Australian population.

Standards used

Standards are consulted, but in many cases they are too general for application to specific problems. Standards that are liked have clear descriptions of sizing, for example the standards for control rooms (ISO 11064) are prescriptive and provide sizing for elements. The standard provides interpretation of the anthropometric data to arrive at a clear guidance on sizing for elements such as desk heights and footwells.

Other standards mentioned were, Mil 1472, DEFSTAN 009 & 0025, automotive needs to meet SAE J826.

Percentile ranges used

Most people considered 5th percentile female to 59th percentile male to be the normal range to be accommodated. Once the situation needs to go outside of that range, there are usually other factors in play that become more important. People were also aware of universal design principles and the need to have a larger range of sizes addressed, however this can be hard to accommodate in a design.

One person recommended going to 97th %ile for train operators to account for the larger males in this population. In another situation, the nature of the machinery meant that the volume for the person was fixed and could not be changed. (a piece of maintenance equipment that need to fit into a particular space).

In practice the percentile ranges provide context to justify how and why environment dimensions are chosen and the risks of not meeting certain accommodation levels, and also describe alternate solutions.

In the automotive industry, the percentile ranges are not reflected in the RAMSIS DHM and the SAE manikin as these are outdated, the designers know the 95th%ile is taller and this is accommodated in the design process.

The understanding of body proportions and how they are related was described by a few of the people who had expertise in anthropometry. They did mentions that some people were scaling DHMs to 95%ile height assuming that 2 of the body segment dimensions scaled in the same proportion, and that they did not need to adjust other dimensions.

Other factors (clothing, other clearances)

There was a common comment that accommodation for clothing was a challenge, and that a authoritative and clear standard that was available to all would be very valuable and eliminate a great deal of uncertainty. People mentioned using BodySpace: Anthropometry, Ergonomics and the Design of Work (Stephen Pheasant). Military standards were also mentioned as having good recommendations for gloves and clothes.

It would be good if information about required allowances could be codified assumptions made clearer. This was part of an overall preference for clear sizing recommendations backed up by an explanation for how the dimensions were developed and provenance of the process and anthro data used. Everyone understands that these figures are not accurate but it would be useful is everyone agreed on the same figures.

The typical clothing to be considered is winter coats, boots, hi-vis vests, gloves and backpacks for rail workers. Typically, people used 25mm for boots and 25mm for jackets, but extra accommodation is required for two layers. In cases with unique equipment, they will measure the items to inform the allowances. Given the ambiguity there is a practice of 'giving it an inch' and providing extra allowance.

In the automotive industry, there is more depth of knowledge and designers make allowances for different vehicle categories, for example in pick-up trucks extra room is made in the footwell to account for people wearing work boots in these vehicles. The DHMs used in the automotive area have allowances built in so they are visible in the CAD environment.

Use of Digital Human Models (DHM)

DHMs were only used by few of the interviewees.

DHMS are most often used by contractors and manufacturers. They are used to justify and provide assurance for designs. People outside of the consultants and manufacturers do not have access to CAD and DHMs, and some asked for simple and easy tools to use. In these cases they use the figures from the data against the drawings provided by the engineering teams.

Most people are cautious about the use of DHMs as the final arbiter of decision making for design. Some examples were given where designs relied on DHMs for development and problems were found later on. DHMs are seen as a useful stage in design, to indicate where there may be fit issues, however if there are safety critical or important issues then it is expected that a physical prototype should be used in addition to the DHMs.

In-house anthropometric data

Queensland Rail did an internal data gathering project about 10 years ago for their operators and line workers. It is recognized this is a small sample and a bit out of date, but it was useful to indicate that this population was at the upper end of the anthropometric range. There was a comment that they did not want to assume this would always be the case (this user group is ageing and retiring soon), so using the lower end of the database remained important.

Many people did not gather their own data, in some cases because they were aware of the challenges of doing this properly in terms of accessing people, sample sizing and doing the data analysis.

On once case a person did a sample of 10+ people to address specific concerns about train cab seats, in this case these were task-specific such as sitting eye height and popliteal length.

Physical prototypes

Only a small number of interviewees did use physical models. In most cases they did not have the facilities and capacity to do it, and relied instead on paper base assessment and evaluations. One of the interviewees liked to go to a prototype is possible and tried to get it included in project budgets, but it was not always feasible.

It is understood that for cabin design and reach for controls, a physical model was better at evaluating a design than a digital one. There were experiences where the physical model and DHMS analysis gave different results.

Bucks are always used in the automotive industry. SAE J826 includes specifications for a physical human manikin for evaluating the driving position. In automotive there is a great deal of collective knowledge and once a car interior is established the basis of the layout will be used in future projects.

Participant selection for physical testing

If selecting people to do user trials of physical models, interviewees will choose participants that reflect the 5th%ile female and 95th%ile male, typically based on stature alone. If this is not possible the people that are as close as possible are used, and their body dimensions are used to locate them in the dataset. This provides context and discussion for the analysis and caveats for the recommendations. Some people had contact lists for people at the extreme body sizes that could be called on to participate in trials.
A tool that enables people to identify participants and compare peoples' body sizes to databases to aid in the analysis would be valuable.

Processes used in design assessment

There is a wide range of processes used depending on the organisation, the context, the nature of the problem and the types and relations between the teams. Processes also depend on whether the work is design development, or assurance of other work.

One process that was described that appears to be indicative of most other is as follows. First the problem statement is examined and the use context is deemed safe or unsafe. Derived requirements are produced, e.g. "this is accessible to people of a certain height".

People need to understand the context, use goals and equipment, and need to spend time to clarify the context. If the problem is simple, the existing specification can be used. Where the situation has a safety risk or includes complex human interactions, more detailed investigations and work are required. For many situations, precedents or sizing specifications can be used, the anthropometric data is only consulted when the situation is novel and not covered by existing guidelines.

Recommendations for future Human Factors development

There is a great deal of infrastructure being built, and there are not enough Human Factors (HF)professionals to go around. It is important to build awareness of the issues across the organizations so that more people can identify HF issues and know when and how to access HF support.

PeopleSize has a variety of 'standard' positions, but interviewees would like more non-standard positions such as crouching and reaching. They would also like more position ranges in PeopleSize so there are more options to match to the user scenarios, particularly more extreme postures.

It would be useful for PeopleSize to derive dimensions when the data is not there, by aggregating data to derive a dimension not present in the body measurement. People are aware of the issues when aggregating data, and that it is not always as straightforward as adding and subtracting dimensions.

Interviewees access clothing data from countries with colder weather as their clothing allowances are likely to be more informed. A data set for the Australian Rail industry would be very beneficial.

They are aware that females and children are underrepresented but it is important to have this data for safety on the train platforms.

Providing data in a tabular form is not desirable. It makes it hard to access the data and be confident it is being interpreted properly.

Standards for physical items are often outdated and do not reflect current and future technologies and these need to be revisited to make them more relevant. Recommendations need to include information about the provenance of the information to aid in the interpretation of the data for a particular context.

There are a variety of users, from people doing the physical design with access to CAD and DHMs who use the data often or are very familiar with anthropometry, to users with Psychology backgrounds who understand the principles but do not use of access the data often. They would benefit from more structure and guidance to remind them of how to use the data and guide them on which data is relevant for particular scenarios. “Have you considered these 5 things before ‘pushing the button’ on the final figure?” In this case it may be risky for non-HF personnel to do this, but in some cases perhaps “the best is the enemy of the good”.

An easy to use UI is important for these infrequent users. Providing heuristics and general guidance would be useful and enable non HF people to do some preliminary HF work on simple designs and help them identify when the need to reaching out to HF professionals for more complex work. Images of the data is vital to aid with the interpretation and implementation. Guidance and caveats on how to interpret the data would be very useful and aid in how reporting of recommendations is developed.

Being explicit about provenance and assumptions is very important. In this case it is not necessarily wanting to know where the data from, but have also some indication of confidence and where you need to be aware that some dimensions need to be treated and interpreted differently than others. Part of this, for example, is understanding how and when figures can be rounded to the closest 5 or 10 mm.

It would be useful for the UI to present images and dimensions that can be screen grabbed for inclusion in reports. The general consensus was that the PeopleSize UI was good and the visual way to present the information worked very well. Any new anthro data should use this as a starting point. For advanced users it would be good to have the ability to develop boundary mannequins via multivariate algorithms and visually represent the data as well as output DHMs. The naming of the dimensions should be in plain English and the nature of the measurement should be made clearer. “This measurement is from here to here and it is useful for these types of activities”. If conducting a user trial, it would be useful to include a guide to which dimensions should be used to identify a person to do an evaluation.

Everyone accepts the challenges of choosing and interpreting the data, and that there are many steps and decisions. In these cases, the project description requires a narrative showing how the data was interpreted and assumptions made. Everyone accepts this is important and that people have the ‘right to be wrong’ as long as they are explicit in their reasoning so that people ca back track and offer alternative interpretations.

Summary

Overall, the range of applications within the transport industry is extremely broad, ranging from vehicle interiors to passenger carriages, driver consoles, general public areas around public transport, to office and building spaces. Methods and processes are equally diverse. In a sense, anthropometry - and other human physical data such as flexibility- represent the last common ground of all these application areas. The interpretation of anthropometry, which is necessary to design and assessment processes, is specific to each area and scenario. But a common anthropometric database would benefit all areas equally.

PeopleSize appears to be the most commonly used software for anthropometry purposes. We (UniSA) acquired a copy of the software as part of the project. PeopleSize provides anthropometric data in various postures (for a total of about 200 dimensions) for a large number of countries, by age group and sex. In our experience, the software should be seen as a user-friendly interface to a large collection of anthropometry databases. It should not be seen as a design tool, or a human factors tool, since it does not provide any interpretation, context of use, for the anthropometric data. It is still a valuable tool as it provides an easy way to access rich anthropometric data.

Since PeopleSize provides anthropometric data for Australian adults, one of the goals of this phase of the project is to assess the validity of PeopleSize Australian data against the Australian National Health Survey (NHS) data (see next section).

There was a strong demand for clearer, or at least more consistent, guidelines on clothing and other correction factors in design requirements. This is something that should potentially be examined in a later phase of this project.

Overall, most key personnel did not use any 3D CAD or DHM tool to aid in design assessment. This was due in part to this being only a fraction of their overall responsibilities. Specialist software requires time investment to learn, and license costs can be prohibitive. The most common approach was lining up anthropometric dimensions against paper prints of designs. We should not expect end-users to be able to afford enough time to become experts in such tools. Similarly, physical prototyping was seldom used for the same time and financial reasons.

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Data scoping

In this phase of the project, we scoped available anthropometric data for the Australian general population. We extracted data from the two large National Health Surveys (NHS 2014 and 2017). We describe data extraction procedures, and compare the data to the PeopleSize database. We initially targeted the following potential data sources:

Public surveys (e.g. NHMRC) containing anthropometry data

We scoped the list of NHMRC Project and Ideas grant funded since 2019[1] for projects including measures of participants' anthropometry.
Initial scoping was performed with *ad hoc* rules as follows:

- Grant type: Ideas grant (i.e. project),
- Study title suggests targeting the general population and/or a healthy/non-pathological group (e.g. healthy children),
- "Broad research area" is "public-health". Most projects are medical related, e.g. "chemotherapy" and "cancer cell biology" can be safely excluded since the study population is unlikely to be the general public.

This last condition allowed to discard most of the studies on a first pass: approximately 15/300 funded Ideas projects each year had a "public health" research area. Most of these were again discarded after screening the project titles, due to a "non-general" target population (e.g. pregnant women).

We contacted 6 academics through email, who were listed as chief investigators on the relevant remaining projects. 2 projects only had objectively measured anthropometric data:

- One study was of approx. 300 school-aged children (10-12 y.o.); height and weight were measured by research assistants at study start;
- One study of approx. 375 adults (25-50 y.o.); height and weight were measured by the participants themselves using stadiometer and scales, and collected by the research team.

Overall, given that:

1. The sample sizes are much smaller than the National Health Surveys (NHS, see below): 300 vs. >10,000, meaning adding these datasets wouldn't add much statistical power overall;
2. They do not offer more anthropometric measurements than the NHS, which also contains height and weight, plus waist circumference;
3. The studies don't report a protocol for measuring height and weight;

We decided that these studies did not offer enough statistical value, compared to the NHS datasets, to be worth adding to the latter, especially given extra considerations around clustering and age group distributions would need to be taken.

[1] https://www.nhmrc.gov.au/funding/data-research/outcomes#download (retrieved 06/2022)

Australian Anthropometry Database (AADBase)

In 2002, an effort was made by a number of Australian academic institutions to measure the Australian general population[2]. A total of 1408 participants were measured, with a vast majority of females (1320). This include all age groups: as per the authors, “participants of both sexes and all ages were recruited at craft fairs”. Overall, the sample size is less than 10% of each of the NHS’ surveys timepoints.

Importantly, 60 individual anthropometric measures were collected in this study. As such, the study’s potential value resides in examining the correlations between anthropometric measures, which could possibly inform data extrapolation from the main NHS datasets. One must keep in mind the potential biases in the dataset due to recruitment methods and the (most likely related) very large proportion of female participants.

Sizing Up Australia

“Sizing up Australia” was an initiative funded by Safe Work Australia to collect representative anthropometric data for the Australian population. They have provided reports defining potential scope of use and guidelines for harmonization of data collection and use, but as of today have not collected large-scale anthropometric data.

NHS: the Australian Bureau of Statistics’ National Health Surveys

The National Health Survey (NHS), run by the Australian Bureau of Statistics (ABS) collects a variety of information about the health and wellbeing of people in Australia.

Every three to four years, a sample of Australians are asked to complete a survey, and an ABS interviewer collects additional information during a home visit. During this visit, voluntary measurements of height, weight and waist circumference were collected by the ABS employee.

Despite the fact that body size measurements were done on an opt-in basis, resulting in about 30% non-response rates (i.e. decline to participate) across time points, the NHS datasets provide by far the largest sample sizes for body size in the general Australian population: 18,500 and 20,600 for the 2014 and 2017 timepoints, respectively.

Given the small sample sizes of other datasets compared to the NHS, and considering the cost-benefit value of harmonizing datasets, we elected for this first phase of the project to focus on analysis of the NHS datasets only. The goal is primarily to assess the representativeness of anthropometric data used in the Australian Transport Industry, and for this aim the NHS data are the most representative. We plan to analyse the AADBase data in Phase 2 of the project to inform potential imputation methods.

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[2]Henneberg, M. and Veitch, D. National size and shape survey of Australia. *Kinanthreport*, *16*(1), 2003.

The NHS datasets

NHS survey methods

More details on the NHS methods can be found on the ABS website[3]. Information specific to anthropometry data collection can be found on that page under Appendix 2. We summarise the main points and important details here.

Regarding general sampling for the NHS, "*The NHS was conducted from a sample of approximately 21,300 people in 16,400 private dwellings across Australia. Urban and rural areas in all states and territories were included, while Very Remote areas of Australia and discrete Aboriginal and Torres Strait Islander communities were excluded*."

Dwellings were selected at random using "a multistage area sample of private dwellings". The ABS states that the sampling ensures representative cover of geographic and demographic characteristics.

Anthropometry was measured during the home visit by an ABS interviewer. According to the ABS, "*voluntary measurements of height, weight and waist circumference were collected from respondents aged 2 years and over*", which we interpret to mean every household member present at the time, and willing to have their body size measured (or their parents' consent for minors) took part. Note that for the general NHS survey (non-anthropometry) the ABS indicates that "*within each selected dwelling, one adult (18 years and over) and one child (0-17 years) were randomly selected for inclusion*" which conflicts our interpretation above.

Despite this lack of clarity, our data analysis (see further below) shows that the age distribution of the NHS cohorts is extremely close to the UN estimates[4].

The ABS does not specify how many interviewers performed the home visits and anthropometric measurements, nor whether they received training in anthropometry. There is also no mention of a protocol, aside from a stadiometer, scales and girth tape used to measure height, weight and weight circumference respectively.

There are four timepoints for which anthropometry data are made available by the ABS: 2007-08, 2011-12, 2014-15, 2017-18. For brevity, they will be referred to by their start year throughout the present report.

Accessing the NHS anthropometry data

Researchers who wish to use NHS data need to undertake some security training by the ABS, then submit their project proposal, including variables of interest and an analysis plan, to the

[3] https://www.abs.gov.au/methodologies/national-health-survey-first-results-methodology/2017-18
[4] https://population.un.org/wpp/Graphs/DemographicProfiles/Pyramid/36

ABS. Once the project gets approved, researchers can get access to the NHS data through a virtual machine.

We successfully obtained access to the NHS datasets for 2008, 2011, 2014 and 2017. One project member (FF) was granted access to unreleased data, while two others (CK and AF) were granted the right to discuss, but not access, unreleased data.

Limitations on NHS data (ABS output clearance rules)

NHS data is confidential until going though the ABS release approval process. Researchers need to complete the data extraction and analysis on the virtual machine. There are a number of rules set by the ABS, which data must satisfy in order to be released. These Output Clearance Rules[5] mostly pertain to sample sizes: for instance, the "rule of 10" states that each statistic should have at least 10 unweighted contributors.

Output Clearance Rules limit the granularity at which NHS anthropometry data can be made public. For instance, when analysing specific age groups, care must be taken to select an age range wide enough that sample sizes are sufficient. Splitting the analysis by sex further increases the sample sizes constraints.

In this phase of the project, we are interested in descriptive statistics. Generally speaking, the clearance rules do don't pose an issue with mean, median, and standard deviation. However, the percentiles are subject to stricter sample size requirements than the "Rule of 10". Sample size requirements for percentiles are as follows:

Minimum contributors for percentiles

Percentile	Minimum contributors
0.01	500
0.05	100
0.10	50
0.25	20
0.50	10
0.75	20
0.90	50
0.95	100
0.99	500

Figure 1 - minimum sample sizes for percentiles, from the ABS output Clearance Rules[5].

The above means total sample size should be approximately 50,000 in order to release the 1^{st} and 99^{th} centiles' data; approx. 2,000 for the 5^{th} and 95^{th}, and approx. 500 for the 10^{th} and 90^{th}. With the NHS datasets around 10-20,000 total sample size, this means the 1^{st} and 99^{th} centiles cannot be released, and depending on age group and sex splits, the $5^{th}/95^{th}$ and $10^{th}/90^{th}$ sometimes cannot be released either.

[5] https://www.abs.gov.au/statistics/microdata-tablebuilder/datalab/input-and-output-clearance#output-rules

These percentile requirements are a significant restriction, given the final intended use of the data. For Human Factors considerations, the extremes of body sizes and shapes are often more relevant than the averages. For instance, assessing an accommodation level is usually done by checking the suitability for small females (of children, if applicable) and large males. Typical associated anthropometry percentiles are 5th and 95th, and sometimes up to 1st and 99th in critical environments.

For children in particular, ABS percentile restrictions have a large impact. The age groups need to be narrow enough to take growth into account: e.g., the median height of all children age 2 to 18 is not particularly useful. On the other hand, too narrow age groups make it impossible to release the extreme percentiles of anthropometry.

Age group splits

In the present report, we aimed at using **age group splits** that would allow a satisfactory compromise:

- **For children** (2-18 y.o.), **every 2 years** of age, e.g., 2-3, 4-5, … 16-17 years old. These splits allowed to release up to the 10th and 90th centiles without splitting by sex, and the 25th and 75th when splitting by sex.

- We also used 2-9 and 10-17 y.o. age groups, which allowed us to release the 5th and 95th centiles (although again, the relevance of these data is questionable).

- **For adults** (18+), we used the **same age group splits as available in PeopleSize** since it is the most commonly used software in the Australian transport industry: 18-64, 18-25, 18-39, 25-50, 40-64, 65+, 65-74, 75+, 85+ years old.

Anthropometric data imputation by the ABS

As mentioned earlier, the non-response rate for anthropometric measurements in the NHS 2014 and 2017 surveys was approximately 25-30%.

Missing values were imputed by the ABS[6] *"using the "hot decking" imputation method"*. Missing records received the value of a similar record based on age, sex, location, self-perceived weight and BMI[7], self-reported level of exercise, and cholesterol level (7 variables). The ABS indicates that *"86% of imputed records with self-reported BMI used all seven variables to match to a donor record"*.

[6] https://www.abs.gov.au/methodologies/national-health-survey-first-results-methodology/2017-18#appendix-2-physical-measurements

[7] Self-reported BMI was used for NHS 2017 only.

The accessible NHS data contains these imputed values, to our knowledge there is no way to isolate the imputed data from the measured. This means for the 2014 and 2017 datasets, approximately 75-80% of the data access was physically measured, and 25-30% was imputed.

The ABS provides estimates of the impact of the imputation on the anthropometric data (Figure 2):

Body Mass Index category	Measured only				Measured and Imputed Using 2017-18 imputation method			
	2-17 years	2-17 years	18 years and over	18 years and over	2-17 years	2-17 years	18 years and over	18 years and over
	(no.)	(%)	(no.)	(%)	(no.)	(%)	(no.)	(%)
Underweight	174	7.2%	123	1.1%	325	7.6%	189	1.2%
Normal	1604	66.7%	3370	31.1%	2846	66.4%	4968	30.3%
Overweight	424	17.6%	3903	36.0%	758	17.7%	5837	35.7%
Obese	202	8.4%	3446	31.8%	359	8.4%	5376	32.8%
Total	2404	100.0%	10842	100.0%	4288	100.0%	16370	100.0%
Total overweight/obese	626	26.0%	7349	67.8%	1117	26.0%	11213	68.5%
						Whether measured		
Measured	2404	56.1%	10842	66.2%	..	..	..	..
Not measured	1884	43.9%	5528	33.8%	..	..	..	..
Total	4288	100.0%	16370	100.0%	..	..	..	..

Figure 2 - Measured vs. imputed BMI for the 2017 NHS survey. Source: Australian Bureau of Statistics, National Health Survey: First Results methodology 2017-18 financial year[8].

Overall the effect on BMI is relatively small, with 0.7% more adults in the “overweight or obese” category (BMI > 25) and 0.7% less in the “normal or underweight” (BMI ≤ 25). This trend is in line with the ABS mention of a bias of non-respondents toward larger BMI values.
Once again, in the data we accessed there was no distinction between measured and imputed records, so we weren’t able to further quantify the effect of imputations.

Data extraction procedure

Data extraction and analysis were performed in R on the allocated ABS virtual machine.

[8] https://www.abs.gov.au/methodologies/national-health-survey-first-results-methodology/2017-18#appendix-2-physical-measurements

For each of the 4 timepoints, variables of interest were:

- age (years),
- sex (M/F),
- weight (body mass) (kg),
- height (stature) (cm),
- waist circumference (cm).

First, the corresponding NHS variable names and definitions were identified and extracted from the data dictionaries for each timepoint (Figure 3).

Australian Bureau of Statistics

4324.0.55.001 Microdata: Australian Health Survey, National Health Survey, 2011-12, Expanded CURF Data Item List

Table 11 Person level items - Physical measurements and body mass

SAS name	Items & categories	Main population
PHDCMH2	**Measured height (cm)**	All persons aged 2 years and over
	000. Not applicable	
	Continuous values from 80 to 210 cm (one decimal)*	
	997. Measurement not taken - equipment faulty	
	998. Measurement not taken - refusal	
	999. Measurement not taken - other reason	
	* Males aged 18 and over: 146 = 146cm and under. Females aged 18 and over: 138 = 138cm and under. Males aged under 18: 190 = 190cm and over. Females aged under 18: 180 = 180cm and over. All persons aged under 18: 80 = 80cm and under.	

Figure 3 – example data dictionary for the 2011 dataset. Height (cm) has variable name PHDCMH2; continuous values from 80 to 210cm, and specific codes for missing data.

The five corresponding data fields were imported in R. Total sample size and number of females were calculated.

Participants with invalid anthropometry data were discarded. This included all participants with an invalid flag on any of the three anthropometric measures of interest: e.g. as shown on Figure 3, a value of 0 or 997-999 for height in NHS 2011 was invalid. Sample size and number of females were again calculated for valid participants.

Descriptive statistics for weight (kg), height and weight circumference (cm) were extracted for each age group. **Age groups** were described earlier (*Age group splits*, page 5) and are summarised again here:

- Children: 2-year groups from 2 to 17: 2-3, 4-5, …, 16-17 years old;
- Children 2-9 years old, 10-17 years old;
- Adults: 18-64, 18-25, 18-39, 25-50, 40-64, 65+, 65-74, 75+, 85+ years old.

Statistics extracted were:

- Sample size (n) and number of females;
- Median, mean and standard deviation (SD),

- Percentiles: 1st, 5th, 10th, 25th, 50th (median), 75th, 90th, 95th, 99th;
- Sample size for each percentile (to check against ABS output clearance rules).

Outliers were removed for each age group, by discarding participants more than 3 Standard Deviations (SD) away from their group's mean. We opted for an SD-based approach to outlier removal, as opposed to a quartile-based approach (interquartile Ranges) since the data overall tended to display long tails on either end of the distribution.

Descriptive statistics were computed again with outliers removed. Percentiles in particular were examined to assess whether outlier removal had any effect.

Finally, descriptive statistics were also computed for **males and females** separately for each age group.

The R script checked if each percentile satisfied the ABS minimum requirements for percentiles (see above) and deleted the value if not. All data were written to CSV files (one per timepoint) which were submitted to the ABS for release.

NHS 2007

After the first pass of data extraction, the NHS 2007 anthropometric dataset was found to have three major limitations:

1. A significant number of missing data (non-response): out of 20,788 total participants, only 10,984 (53%) have complete anthropometric data. This large amount of missing data not only makes data quality more questionable, it also causes more issues with the ABS sample size requirements for percentiles since the overall sample is smaller. For most children age groups only the 25th, 50th and 75th percentiles could be obtained.

2. Measurements of height, weight and waist circumferences had upper and lower limits, and values beyond these limits were clipped:
   - For weight, adults <40kg were recorded as 40kg, and >140kg as 140kg;
   - For height, limits for adults were 145 to 200cm.

   The ABS indicates those were due to limitations of the instruments themselves. In practice this affected 71 adults' records for weight and 41 for height, with again the added consideration that extremes are more important than averages in regards to human factors.

3. Finally, and perhaps most importantly, waist circumference was only available in categories of 10cm increments, starting at <40cm, 40-49cm, … 140cm or more (with again, values clipped outside of 40-140cm).

The bounds of measures of height, weight and waist circumference make it difficult to examine the extremes of anthropometry, and the fact that waist circumference data is categorical makes future data imputation / interpolation very challenging. For these reasons, decision was made (FF in agreement with AF) not to use the NHS 2007 data any further. Data release was not requested to the ABS for this timepoint.

NHS 2011

The 2011 dataset shows improvement on data completeness, with 20,426 total participants and 15,875 with complete anthropometric data (78%, vs. 53% in 2007.) However, it still uses the same upper and lower bounds for anthropometric measures (age and sex dependents for adults' height, 40-150kg for adults' weight, 40-140cm for waist circumference). Once again these limits make it too problematic to use the data in our context, and like for the 2007 dataset we decided not to request data release from the ABS.

NHS 2014

The NHS 2014 includes 19,257 participants, of which 18,594 (97%) have complete anthropometry data. Please note that, as described earlier, this includes 26.8% of imputed data (non-response). There are no limits on height, weight and waist circumference measurements.

NHS 2017

NHS 2017 includes 21,315 participants, of which 20,658 (97%) have complete anthropometry data. This includes 33.8% of imputed data (non-response). There are no limits on height, weight and waist circumference measurements.

We computed all anthropometry summary statistics and percentile values as described above for the **2014 and 2017 timepoints**, and were granted output clearance by the ABS. Results are presented in the next section.

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Results: NHS 2014 and 2017 anthropometric data

The full NHS 2014 and 2017 anthropometric data are available in Appendix 1.

Important note on percentiles presented

The section below provides anthropometric percentiles from the NHS surveys data. Human factors and ergonomics considerations are most often concerned with the extreme ends of users, that is, the 5th and 95th percentiles usually, and the 1st and 99th in some critical scenarios. The 50th percentile (median) can also be used as starting points / reference cases. For these reasons, we aimed at presenting the extreme percentiles (5th/95th) as well as the median when possible. However, ABS rules on sample sizes for percentiles means it was not always possible. In that case we report the most extreme percentiles available.

In practice: for children, we present the 25th, 50th and 75th centiles since ABS sample size rules did not allow us to extract more extreme centiles for 2-year wide age groups when split by sex. For adults, we present the 5th, 50th and 95th centiles which have more relevance to human factors / ergonomic considerations. However the 5th and 95th percentiles were not always available for the older adults age groups due to the ABS same sample size restrictions.

Effect of outlier removal

As mentioned earlier in the report, we removed outliers for each age group by discarding participants with height, weight or waist circumference more than 3 SD away from their group's mean. Percentiles were computed with and without outliers. Table 1 below present a summary of the results. We only present two children and two adult age groups for brevity; effects were identical in all other age groups (see Appendix 1 for the complete results).

Overall, the effect of outliers on percentiles was nonexistent or negligible. For adults (18+), the largest effects were 0.9cm, 3.1kg and 2cm for height, weight and waist circumference percentiles, respectively. Most effects were of much smaller magnitude. The corresponding weight and waist circumference percentiles were the 95th in 2017.

We know that the distribution of weight and waist circumference data in adults tend to skew to the right (i.e. a long tail of few extremes in the high values) in developed countries, and visual examination of the NHS data distribution confirmed this (although we cannot release this distribution). In that sense, the fact that outlier removal had most effect on the 95th percentiles for weight and waist circumference is no surprise. It is plausible that the "outliers" removed

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were actual values, only part of the long right tail of the distribution. Conversely, height data tends to be less skewed and this is reflected by an overall much smaller (or nonexistent) effect of outlier removal on height percentiles, most of them staying identical.

In children the same small to nonexistent effects are observed. Largest effects of outlier removal are 0.9cm, 0.8kg and 0.7cm for height, weight and waist circumference percentiles, respectively. The corresponding weight and waist circumference percentiles were the 75^{th} centiles for 10-11 years old in 2017. The same conclusions can be made as for adults, regarding the right skew of weight and waist circumference and removal of outliers that were potentially a natural part of the right tail.

Overall, the effect of outlier removal was small. The largest effects were observed in the largest percentiles (75^{th} or 95^{th}) of weight and waist circumference. Most other effects were negligible. Given that it is unclear whether these outliers were erroneous, or actually part of a naturally right-skewed distribution, **we opted to *not* remove outliers** in the data we present.

		2014									2017								
		Height (cm)			**Weight (kg)**			**Waist circ. (cm)**			**Height (cm)**			**Weight (kg)**			**Waist circ. (cm)**		
Children																			
	Outliers?	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th
6-7 years	included	119	124.1	129.9	22	24.7	29.1	53.5	57	61	116	123	129	21.4	24.3	28.9	53.5	57	61
	excluded	118.9	124	129	21.9	24.5	28.7	53.4	57	61	116	122	128	21.4	24	28.3	53	56.9	61
10-11 years	included	142.4	147	152.5	34.6	40.3	48.2	61.2	66.5	73.2	140.2	147	152	33.8	39.4	47.1	60.1	65	73
	excluded	142.4	146.7	152.4	34.6	40.2	47.7	61	66.5	73	140	147	152	33.5	39	46.3	60	65	72.3
Adults																			
	Outliers?	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
18-64 years	included	154	169	185.9	53	77.1	114	69	90.1	118.5	153	168	185	52.7	77.8	116	69	91	121
	excluded	154	169	185.5	53	76.9	111.4	69	90	117	153	168	185	52.7	77.4	112.9	69	91	119
65+ years	included	150	164	181	52.5	74.9	106.4	75	96.2	121	148	163	180	52.3	75.9	107.5	75	98	123
	excluded	150	164	180.5	52.5	74.7	104.4	75	96	120	148.9	163	180	52.3	75.7	106	75	97.8	121.1

Table 1 – effect of outlier removal on anthropometry percentiles for the NHS 2014 and 2017 timepoints.

Summary results

Table 2 below provides summary descriptive anthropometric data (height, weight, waist circumference) in the Australian general population, from the NHS 2014 and 2017 surveys.

The full results (all children and adults age group percentiles, mean and standard deviation, per sex) are available in Appendix 1.

We only present a few selected age groups here:

- Three children age groups (6-7, 10-11, 14-15 years old), evenly spaced, and who might represent "boundary users" for some transport human factors considerations.

- Adults 18-64, 65+, and 75+. The 18-64 group is further split into 18-39 and 40-64. Increases in weight, BMI and waist circumference are common as adults age, while height stays the same, so this age group split provides some insight into these trends globally. The 40-64 age group might also be of interest as some stakeholders indicated the train driver population is majoritarily composed of Caucasian middle-aged men.

Sex differences in anthropometry in children are negligible at 6-7, become apparent at 10-11 years old, and significant at 14-15 years old, approaching those of adults. 14-15 years old girls are on average 9cm shorter and 5kg lighter than same age boys in 2014 (4kg in 2017).

In NHS 2014, the average Australian 18-64 year old male is 1.77m and 84.8kg, 18-64 females are 1.64m and 69.1kg. In NHS 2017, averages of the same groups are 1m75 and 85.8kg (males) and 1.62m and 68.9kg (females). Males and females were 1.7 and 1.5cm shorter in 2017 compared to 2014, respectively. This is a rather strange result considering secular trends as well as the large sample sizes for these age groups. It is also worth noting that differences are much smaller for the extreme percentiles (5^{th} and 95^{th}). Males were also 1kg heavier in the 2017 survey. For females the difference was only 0.2kg.

Older adults age groups (65+ and 75+) tend to be overall smaller and shorter than younger adults. For height, differences between the 2014 and 2017 datasets follow the same unintuitive trend as for younger adults, with the 2017 cohort between 1-3cm shorter than the 2014. Differences in weight are ±1kg between the two time points and do not follow a trend.

NHS 2014																			
		Male									**Female**								
		Height (cm)			**Weight (kg)**			**Waist circ. (cm)**			**Height (cm)**			**Weight (kg)**			**Waist circ. (cm)**		
Children																			
	n (F)	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th
6-7 years	471 (214)	119.4	124	129.5	22	24.8	29.1	53.6	57.6	62	118.6	124.5	130	21.7	24.4	29.1	53.5	57	61
10-11 years	455 (224)	141.8	146.7	152.5	34.8	41.4	49	61.8	67.5	75	142.9	147.5	152.5	34.6	40.1	47.5	59.5	66	70.3
14-15 years	519 (237)	165.3	172.1	177	54.6	62.8	71.3	71.2	77	86	159	163.1	168	51.7	58	67.8	67	72	78
Adults																			
	n (F)	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
18-64 years	11k (6k)	165	176.7	188.5	63.1	84.8	119.3	78	95.6	122	151.7	163.5	175	50.4	69.1	105.7	67	85	115
18-39 years	5k (2.7k)	165.4	178	189.5	60.8	82.7	119.4	75	90.5	117	152.5	164.4	176	49.1	66	104.3	65	80.2	112.2
40-64 years	6k (3k)	164.5	175.9	187.5	66	86.4	119.2	82	99	125	151.3	162.8	173.5	51.9	71.8	107.1	70	88	116
65+ years	3k (1.8k)		172.3			83.2			102			158			68			91	
75+ years	1.3k (800)		171			79.5			101.8			156.9			65.6			91	

NHS 2017																			
		Male									**Female**								
		Height (cm)			**Weight (kg)**			**Waist circ. (cm)**			**Height (cm)**			**Weight (kg)**			**Waist circ. (cm)**		
Children																			
	n (F)	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th	25th	50th	75th
6-7 years	501 (251)	118	124	130	22	24.4	29.2	54.1	57	61	115	121	128	20.8	24	28.3	53	56	62
10-11 years	490 (235)	140	146	152	33.8	40.1	48.7	61.2	66	75	141	147.5	153	33.8	39.4	46.1	59	64	71
14-15 years	530 (266)	164	171	176.2	52.1	60	71.1	69	75	82	157	162	167	49.5	56.2	64.8	65.4	71	80
Adults																			
	n (F)	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th	5th	50th	95th
18-64 years	12k (6k)	163	175	188	63	85.8	121	77	96	124	151.9	162	173	50.3	68.9	108.5	67	85	117
18-39 years	5k (2.7k)	165	177	189	62	83.4	121	75	92	119	152	163	175	49.3	66	108.2	65	80.6	112
40-64 years	7k (3.7k)	161.7	174	187	64	87.3	121.4	82	99	126	151	161	173	51.4	71.4	108.6	69	89	120.3
65+ years	4k (2.3k)		171	183		82.2		84	103		147	157	169	49.1	69.5	99.4	71.1	93	118
75+ years	1.7k (1k)		168			78.2			101			156			66.6			93	

Table 2 – Summary Australian anthropometric data from the NHS 2014 and 2017 surveys.

Comparison to other countries

It may be of interest to see where the average Australian adult stands in comparison to other countries. We have compiled mean height and weight for male and female adults for some of the largest countries in the world, as well as two European countries (Germany and England). Note that we report mean averages in Table 3, and not median (50th percentile) as this was the most commonly available metric across countries. Values are rounded to the nearest cm and kg.

country	**Mean male height (cm)**	**Mean male weight (kg)**	**Mean female height (cm)**	**Mean female weight (kg)**	Sample population	Year	Reference
China	167	66	156	57	n = 25k age 18+	2015	[9]
India	165		152		n = 190k age 20-49	2011	[10]
USA	175	91	161	78	n = 10k age 20+	2015-18	[11]
Indonesia	164	55	154	49	n = 15k age = 18	2018	[12]
Brazil	171	75	159	64	n = 25k age 35-44	2009	[13]
Japan	172	67	159	51	n = 2k age 25-29	2018	[14]
Germany	179	85	166	69	n = 70k age 18+	2017	[15]
England	175	84	162	70	n = 7k age 16+	2012	[16]
NHS 2014	177	87	163	73	n = 11k age 18-64	2014	this study
NHS 2017	175	88	162	73	N = 12k age 18-64	2017	this study

Table 3 – comparison of NHS 2014 and 2017 anthropometric data to other countries.

We have done our best effort to access and compile general population anthropometric data for the countries in Table 3, with large sample sizes and government-funded studies. All web

[9] General Administration of Sport of China: *2014 National Physical Fitness Monitoring Bulletin*. 2015.

[10] Mamidi RS, Kulkarni B, Singh A. *Secular Trends in Height in Different States of India in Relation to Socioeconomic Characteristics and Dietary Intakes*. Food and Nutrition Bulletin 32(1), 2011.

[11] Fryar CD, Carroll MD, Gu Q, Afful J, Ogden CL (January 2021). "*Anthropometric Reference Data for Children and Adults: United States, 2015-2018*".

[12] Aman B Pulungan, Madarina Julia, Jose RL Batubara and Michael Hermanussen. "*Indonesian National Synthetic Growth Charts*". Acta Scientific Paediatrics: 1(1). 2018.

[13] *Instituto Brasileiro de Geografia e Estatística* – IBGE. 2010.

[14] Japanese Statistics bureau of the Ministry of Internal Affairs: *Physical fitness and athletic ability survey*, 2018.

[15] Federal Statistical Office of Germany (Destatis): *Height, weight and body mass index of the population by sex and age-groups*, 2017.

[16] Moody, A. *Adult anthropometric measures, overweight and obesity*. *Health survey for England*, *1*, 2013.

links for references were accessed 15/06/2022. Pages were translated (Google Translate) when not available in English.

Overall, results are as already known and expected: the average Australian adult has height and weight comparable to Western countries (USA, Germany, England). They are slightly taller and lighter than US adults, and slightly shorter and heavier than European adults. In turn, Australia, USA and Europe are taller and heavier than Asian countries (China, India, Indonesia, Japan).

Comparison to PeopleSize database

The software PeopleSize[17] by Open Ergonomics is the most commonly used anthropometry reference in the Australian Transport Industry Human Factors sector. The software provides 291 measured and derived anthropometric dimensions in various postures, for multiple countries and age groups.

Among these, **PeopleSize provides data for Australian adults** with the following age groups: 18-64, 18-25, 18-39, 25-50, 40-64, 65+, 65-74, 75+, 85+ years old (see also Methods section above). PeopleSize cites as reference Australian data "*2017-2018 Government health survey*"[18]. The most likely is the data being from the NHS 2017 survey, although we haven't confirmed it formally with the software authors. It is unclear whether Open Ergonomics obtained access to the NHS data from the ABS and processed the data themselves. We plan to contact them in the next phase of the project to clarify this. We are comparing PeopleSize adult data with results from the NHS 2017 survey.

PeopleSize doesn't provide waist circumference data for Australian adults aged 65+ and 75+. Height and weight are still available.

PeopleSize doesn't provide data for Australian children. We are comparing children data from NHS 2017 with what PeopleSize provides for UK and USA children.

Additionally, for the NHS datasets, we used in 2-year wide age groups for children in order to get the 25th and 75th centiles. PeopleSize provides children data per year of age. We averaged the percentiles given by PeopleSize for children of the two ages in each age group (e.g. PeopleSize 6-7 boys = average of PeopleSize 6 y.o. and 7 y.o. boys) in order to compare with the NHS data directly. We are aware averaging two percentiles isn't mathematically correct; however this was still the most accurate option given the data available.

Comparisons are presented in Table 4.

Australian children overall seem to be as tall as US children and weigh the same as UK children. At 6-7 years, all 3 countries are very similar; at 10-11 the USA and Australian children start to

[17] https://www.openerg.com/psz/index.html
[18] https://www.openerg.com/psz/anthropometric_dates.html

be noticeably taller than UK; and USA children are noticeably heavier than AUS and UK. The trend follows and is magnified for the 14-15 age group. In all three countries the boys-girls differences only get noticeable at the 14-15 age group.

Overall, given the fact that PeopleSize doesn't include children data for Australia, we see significant value in trying to connect with the software authors to include the NHS data we obtained in this project. Even though the differences with US or UK children may be small, there is a benefit adding to the knowledge base, and giving confidence to users that Australian children data is valid.

For adult data, PeopleSize percentiles are close for height overall, for all age groups. For weight and waist circumference, the 50th centiles are close to NHS 2017. The extreme percentiles, however (5th and 95th), tend to be closer to the median ("less extreme") in PeopleSize than in NHS. For example, in NHS 2017, the 95th 18-64 male for weight and waist circumference is 121kg and 124cm, versus 110kg and 117cm in PeopleSize (-9% and -6%). In 18-64 females the differences are 10.5kg and 3.8cm (-10% and -3%). The same effect, although of lesser magnitude, is observed for the 5th percentiles of weight and waist circumference.

Since we don't know how the PeopleSize data were built, we cannot explain the differences with certainty. One possibility is that PeopleSize employed some sort of outlier removal, trimming the extreme values with the effect of bringing the extreme percentiles closer to the median.

Overall, the average Australian adult data in PeopleSize is very close to the NHS 2017 values; we doubt the differences we see here (in the order of 1cm in height, for example) would make much difference in the context of Human Factors, ergonomics and/or quality assurance processes. The extreme percentiles (5th and 95th) however are noticeably less extreme in PeopleSize that what NHS 2017 shows. This could potentially cause issues in design, with the PeopleSize dimensions leading to undershooting the target accommodation level (the error is in the worst direction design-wise).

NHS 2017 vs. PeopleSize data																		
	Male									**Female**								
	Height (cm)			**Weight (kg)**			**Waist circ. (cm)**			**Height (cm)**			**Weight (kg)**			**Waist circ. (cm)**		
Children																		
	25th	**50th**	**75th**	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**	**25th**	**50th**	**75th**
6-7 years																		
NHS 2017	118	124	130	22	24.4	29.2	54.1	57	61	115	121	128	20.8	24	28.3	53	56	62
PeopleSize UK	118.4	122.5	126.5	22	24.5	27.5				117.8	121.6	125.4	22	24.5	27			
PeopleSize` USA	118.2	122.4	126.5	21	24.5	29	53	58.1	63.7	118.1	122	125.8	20.5	24.5	29.5	52.7	58.2	64.6
10-11 years																		
NHS 2017	140	146	152	33.8	40.1	48.7	61.2	66	75	141	147.5	153	33.8	39.4	46.1	59	64	71
PeopleSize UK	139.6	144.5	149.3	33.5	38	44				140.0	144.9	149.8	34.5	39.5	46			
PeopleSize USA	141	146.1	151.1	35	42	49.5	63	70.7	79	140.6	146.4	152.3	34.5	41	50	62.9	69.4	77.1
14-15 years																		
NHS 2017	164	171	176.2	52.1	60	71.1	69	75	82	157	162	167	49.5	56.2	64.8	65.4	71	80
PeopleSize UK	164.5	169.9	175.3	52.5	60	69.5				157.4	162	166.5	49	56	65			
PeopleSize USA	166.4	171.4	176.4	55	66	79	71.2	81	91.8	157.6	162.2	166.8	50.5	58.5	68.5	71	77.8	85.9
Adults																		
	5th	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**
18-64 years																		
NHS 2017	163	175	188	63	85.8	121	77	96	124	151.9	162	173	50.3	68.9	108.5	67	85	117
PeopleSize AUS	165.6	176.9	188.2	67	84	110	79.3	96	116.5	153	163.2	173.5	52	69	98	69.9	87.5	113.2
18-39 years																		
NHS 2017	165	177	189	62	83.4	121	75	92	119	152	163	175	49.3	66	108.2	65	80.6	112
PeopleSize AUS	166.4	177.8	189.2	64	82	107	77.7	94.4	115.1	154	164.3	174.6	49	66	96	67.5	85.4	111.5
40-64 years																		
NHS 2017	161.7	174	187	64	87.3	121.4	82	99	126	151	161	173	51.4	71.4	108.6	69	89	120.3
PeopleSize AUS	164.1	175.3	186.5	70	87	112	81.3	97.7	118	151.5	161.7	171.9	56	72	100	72.8	89.8	114.7
65+ years																		
NHS 2017		171	183		82.2		84	103		147	157	169	49.1	69.5	99.4	71.1	93	118
PeopleSize AUS	161.5	172.2	182.8	68	83	105				147.7	158.1	168.4	53	67	92			
75+ years																		
NHS 2017		168			78.2			101			156			66.6			93	
PeopleSize AUS	160	170.9	181.8	65	80	101				146.3	156.7	167.1	51	64	89			

Table 4 – comparison of NHS 2017 data with PeopleSize database.

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Summary

In this phase of the project, we have gained access to, processed and been granted clearance for the NHS 2014 and 2017 surveys' anthropometry data.

We present summary Australian anthropometric data (height, weight, waist circumference) for 19 age groups for children and adults, split by sex. We include 7 percentiles (5th, 10th, 25th, 50th, 75th, 90th, 95th) when available, as well as mean and standard deviation. **To our knowledge, this is the first time the NHS anthropometry data has been released in such detail**.

Stakeholder interviews showed that PeopleSize was the most commonly used software for anthropometry reference in the Australian Transport industry. We compared the PeopleSize percentile estimates with the NHS 2017 data. The most important points are:

- PeopleSize doesn't provide children data for Australia. Although Australian children are reasonably close to US and UK children, including the actual NHS Australian children data within PeopleSize seems like an efficient way to provide users with actual Australian data. Integrating data to an existing software would cause minimal disruption in workflows.

- For adults, there are noticeable differences in weight and waist circumference in the extreme percentiles (5th and 95th) between PeopleSize and NHS 2017. PeopleSize gives less extreme values for these than NHS: up to 14kg less weight (18-39 males) and 8cm waist circumference (40-64 males) at the 95th percentile. Since design processes often use these extreme percentiles as boundary users, this could potentially cause issues in the design and / or assessment processes, leading to underestimating accommodation ranges. As a next step, we plan to get in contact with the PeopleSize team to discuss methods and possible integration of NHS data.

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Overall summary and future directions

Stakeholder interviews revealed that:

- The range of applications of Human Factors in the Australian transport industry is extremely broad;
- Most key users are familiar with the statistics and meaning of anthropometry, but do not have the time or resources to perform in-depth assessments of space requirements using specialised software (CAD / DHM);
- Most key users rely on the PeopleSize software for anthropometry reference if needed;
- The level of confidence in PeopleSize Australian data is low.

Scoping of Australian anthropometric data showed that:

- The NHS surveys 2014 and 2017 provide by far the largest sample sizes, with a distribution representative of Australian demographics;
- They provide height, weight and waist circumference (as do most other countries' surveys).
- For adults, PeopleSize averages are close to the NHS averages; however, the extremes (5^{th} and 95^{th} percentiles) of PeopleSize are significantly more conservative than what the NHS data shows.
- We obtained NHS data for Australian children, which PeopleSize does not provide.

With the above in mind, the following key elements emerge:

Given that most key users do not have the time or resources to use sophisticated CAD tools, and that the same key users have access to, and use, PeopleSize, this software could be a good target platform to implement updated Australian anthropometry data.

Access to the NHS datasets gives us the opportunity to build a consolidated anthropometry reference base for Australia. To be used in Human Factors however, such reference should contain additional dimensions often used in design assessment, such as shoulder breadth, sitting height, etc.

Multiple options exist to extrapolate missing anthropometric dimensions from others. We propose to examine other datasets with smaller sample sizes but more measurements, such as AADBase, other countries' datasets, or military datasets, to examine the correlations between anthropometric measures. This will help gauge the feasibility of dimension extrapolation.

Importantly, the ABS rules on sample sizes for data output clearance prevent us to obtain the extreme centiles of anthropometry on a large number of age groups, with children being the most affected. We will contact the ABS to discuss the possibility of relaxing these rules in the particular case of anthropometric data. The extreme percentiles are often the most relevant in Human Factors scenarios.