Motorised Scooters for Independent Mobility – Issues of Equipment Design, Driving the Machine, and the Road Environment: A Challenge for the Safety of Impaired Users and the Community.

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ABSTRACT
Motorised scooters were originally designed to improve mobility, particularly for people who could no longer walk long distances in the outdoors.

An overview of the development of the motorised scooter illustrates its changing role and purpose in a society demanding more mobility and accessibility. Design features and the controls are caught between a wheelchair, a bike and a car - moving into the world of vehicles and a traffic environment which is not always conducive to safe travel.

While a percentage of users become competent operators of the motorised scooter, for some, challenges continue to exist which potentially impact upon pedestrian and road safety and the safety of the users themselves.

Issues for discussion include:

- Design of motorised scooters and the operation of controls and accessories;
- Practical implications of design on manoeuvrability and accessibility;
- Position of the motorised scooter in the pedestrian and traffic community;
- Human factors demanded in the safe operation of the scooter;
- Learning to operate a scooter – a complex practical and problem solving affair,

with particular reference to the challenges presented to scooter users who may be cognitively &/or visually impaired.

INTRODUCTION
Motorised scooters were designed to improve accessibility, particularly for people who could no longer walk long distances in the outdoors. With ageing communities expecting improved accessibility and mobility, and with heightening market competition, over time the motorised scooter design, variety and numbers have escalated. The motorised scooter is now an impressive looking machine, with the design of controls and accessories to a degree pushing the boundaries, promoting the impression that it is less of a wheelchair and more of a vehicle, in an image-driven market.

For the population of people who have physical and other functional impairment, and who are living independently or in supported accommodation, mobility out into the community can be a challenging exercise. Social, recreational and activity isolation can result from lack of transport and ability.

In South Australia, approximately 20 years ago the first few scooters became available. Those original scooters were of a basic design – apply a hand brake to stop, lever acceleration, no frills, no accessories – a simple low speed mobility aid, which did not look like a wheelchair.
The availability and number of motorised scooters in this state over the past 5 years has significantly increased, with suppliers in the medical equipment industry promoting scooters from international and Australian manufacturers. Currently, in SA there are approximately 12 suppliers selling over 25 different scooter models.

In 2001-2002, 5000 units (ie electric wheelchairs and motorised scooters) were imported to Australia, of which approximately 10 % were sold in SA. One supplier of motorised scooters (Company A) stated that nationally the number of scooters sold has trebled from 1999- 2002. Company A stated that it had experienced a similar pattern in retail sales. This is a growing industry. Added to these are large numbers of the currently owned/loaned scooters which have accumulated over the years. The second-hand market is very buoyant.
Included in the retail sales are those to the health service and equipment supply organisations, such as Domiciliary Care and ILEC (Independent Living Equipment Contractor – a government funded equipment supply organisation). These organisations have the facility to prescribe, assess and loan motorised scooters to those clients who are considered to have the need and ability to use a scooter. The organisations are then in the position to monitor its use. The numbers and then availability of these service loaned scooters are often limited by the organisation's ability to supply them. Limitations exist in funding and in the priorities of equipment provision.

As there is an open market for motorised scooters, any person desiring one of these 'mobility machines' can easily purchase a new or second hand one. The average cost of a new scooter ranges from $2000 to $5500, and makes it an attractive option particularly when a person is deemed by a medical professional or self assessed as being no longer capable of driving a car. However, once that "initial" cost is paid for a new level of independence, it becomes a very large "cost" to that independence, to give it away.

While a percentage of users become competent operators of the motorised scooter, there continue to exist challenges for some which potentially impact upon pedestrian and road safety, and on the safety of the users themselves. Particularly for users who are visually &/or cognitively impaired, the safe operation and their ability to plan and manage hazards can not be guaranteed due to the complex factors of combining human function, a machine and the environment.

This paper will explore the mixed messages, expectations and perceptions of the motorised scooter user, and the impact and challenges these present to the user, community, road law and the environment. Information presented in this paper is the compilation of clinical observations and experience over a number of years in assessing, prescribing, trailing and evaluating clients using motorised scooters of various ages and abilities.

Where does the motorised scooter sit in the spectrum of mobility from the operator's perspective?
For ease of discussion, consider all users of the road environment to be on a spectrum as follows:

Mobility spectrum

Pedestrian el.wh/ch bicycle motorbike car
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According to Australian Road Rules – Road Traffic Act 1999 a person is classified as a pedestrian when driving a motorised wheelchair or scooter that travels at a speed less than 10 km/hr and that the unladen mass does not exceed 110 kg.

Therefore on the Mobility Spectrum, the position of the scooter appears straight forward according to road law.

Pedestrian el.wh/ch bicycle motorbike car
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I suggest that there are other factors which influence the motorised scooter users' perception and knowledge, and therefore, their decision of where their position as a motorised scooter operator will be when in the road environment. In considering this mode of mobility it is useful to refer to Figure 1 to understand the impacting factors when operating a scooter.

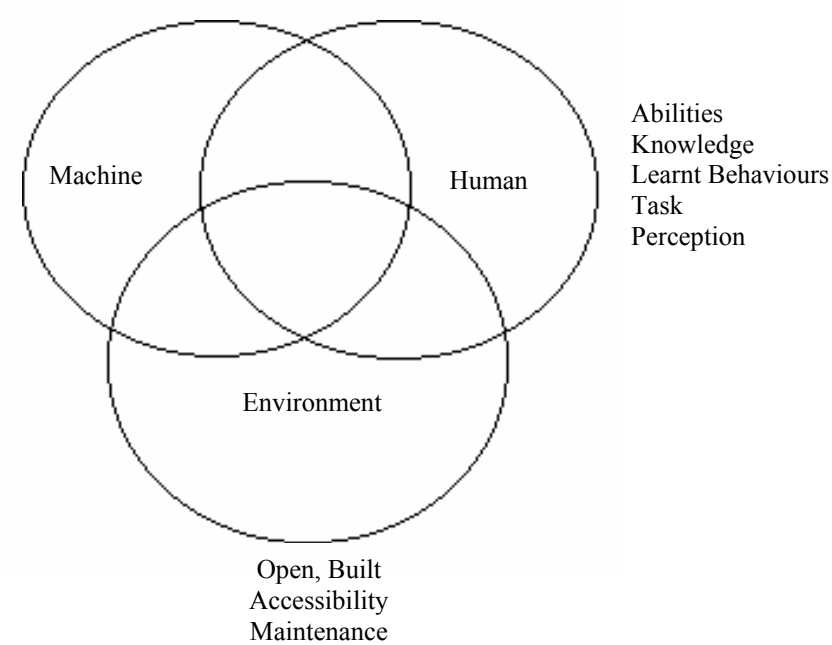

Figure 1

There is an overlap of the aspects under consideration, as each directly affects the other.

1. The Motorised Scooter – (The Machine)

Design of scooter

The dimensions of the scooters have continued to increase to deal with the robust outdoors, and on the expectations of the retail market – size of wheels for clearance over various terrains, length of wheelbase for leg room and stability, availability of 3 and 4 wheeled models. During the 1990's, clients wanted the motorised scooter to handle all terrains, zip about indoors in tight places, carry the weekly shopping with the dog on the front and walking frame on the back, but that it be small and compact so that it can be folded up or taken apart to put into the boot of the car – easily! Have these requirements changed? Maybe some, but users still require that the scooter can act as ½ "vehicle" (to handle the environment) ½ nippy zippy indoor machine (like an electric wheelchair)

Wheelbase – can be 1.5m long but are about the same width as wheelchairs to allow for easy access through standard doors.

Stability of the motorised scooter depends on the design, operational manoeuvres and speed, environmental conditions and its role in use. It is important that operators have a practical understanding of stability of their machine and the factors which directly affect it. This adds to their knowledge base so that they can be in a better position to assess their manoeuvres.

THE MOST STABLE SCOOTER:	**THE LEAST STABLE SCOOTER**:
• 4 wheeled with a long wheel base	• 3 wheeled scooter
• seat forward and in lowest position	• seat position back and positioned high
• travelling on even ground	• accelerating up a hill/gradient
• no additional loads on the scooter	• shopping on the back of scooter
• controlled speed	• heavy weight of driver

Each different scooter offers tailored adjustability to a person. Individual body dimensions and hence personal requirements result in variations of position and weight distribution – More leg room required? Slide seat back. Difficulty getting up from the low seat? Raise seat height
Done the shopping? Put a bigger carrier on the back. These all affect stability**.**

Controls

Scooters are upper limb operated machines. Once seated all the controls are positioned at arms length in front – similar to the layout of a bike - handlebars with levers attached. *The Tiller* consists of the central control panel, handle bars attached at the top with the front wheel(s) attached at the bottom.
The Control Panel usually consists of:

- accelerator lever (usually forward lever on right, reverse on left)
- battery charge indicator and connection bracket
- speed selector, horn , indicator button, lights switch

On the handle bars

- rear vision mirror(s) are mounted on the end

Lights – are useful as an identifying light to alert people to the presence of a scooter. They are not strong enough to use as the sole light source for independent travel out of an illuminated road environment.
Most models now have features such as indicators and rear vision mirrors. The value of their inclusion as a benefit to the operator is worth questioning. Up to 2 years ago few scooters had them and, if they did, they did not always have rear flashing lights.

Indicators are not often seen if used amongst pedestrians as people stand close and have their line of vision ahead and forward. Indicator lights tend to be small and are not always obvious. Recent models have indicator lights observable from front and rear, and are now self cancelling.

Rear vision mirrors are attached to the tiller. Their value, also, is questionable as once the tiller is turned by the handlebars (ie steering) the operator no longer benefits from the vision provided. The mirrors are attached to a moving part, which is often turning right and left. If the small mirrors are adjusted to view behind the scooter, this may be useful only when travelling in a straight line.

It is important to note that these features may provide false comforts for operators who perceive that they have improved safety as a result of their presence. The inclusion and hence the perceptions of some of these features moves the motorised scooter closer to the bicycle vehicle end of the mobility spectrum.

How is the motorised scooter operated?
(An explanation may be useful for those who are unfamiliar)

Acceleration is controlled by finger pressure (thumb pressure on some models).
For *forward acceleration*, the fingers (thumb) squeeze the lever. The amount and speed of hand closure determines the pick-up speed and travelling speed. To continue travelling for a distance, the acceleration lever requires constant and even pressure. In hand function terms, the handgrip is in a ½ open span position and the muscle work required is constant and static. This is tiring, particularly for arthritic hands and upper limb joints. In turn the ability to continue to effectively manage the controls over a period of time can be difficult for some.
When turning the handlebars in order to negotiate a corner or change direction, the hands naturally close to secure the hold on the handlebars to then apply strength to steer. This is the same action for increasing acceleration. There has to be a conscious effort *not* to close the hand as acceleration on a turn, particularly when tight turn and cornering too fast in tight places results in reduced machine stability.
For *Reverse* the left fingers close with a similar squeeze action (or the thumb closes toward handle bars).

Speed Control
Speed is controlled in 2 ways – dial selector and amount of squeeze pressure applied to the accelerator lever. On many models, the speed selector dial on the tiller is graded 1-10, slow to fast. Dials are often very small in size, lack positive physical acknowledgement when turned, and numbers are not easily read which makes accurate choice extremely difficult. Consequently, the frequency and accuracy of use is limited. Habits form in that speed dials remain set at no particular position and the speed is managed purely by the amount of pressure applied to the accelerator lever.

Braking
In the design of the scooter there exists a unique operating feature. There is a park brake, which has the same function as a handbrake, on the rear wheel. Operating brakes are automatic (electromagnetic in design). When pressure is released from the accelerator lever, brakes are activated. With the scooter, to activate the brake is to *let go with the hand* ie release all pressure on the accelerator lever. If squeeze pressure is applied to the lever it accelerates - and fast with the grab reaction.
There is no actual physical existence of a brake to the operator. It is worth noting that if danger looms and a sudden reaction is required, the body will tense - the need is to brake. In *past learned* experience the natural reaction is to **apply** the brake. Refer to Table 1.

Table 1. Action required to brake

Motorised .Scooter	Bicycle	Motorbike	Car
Release finger/thumb squeeze pressure on lever	**Apply** handgrip squeeze pressure on brake lever	**Apply** handgrip pressure on brake lever (/foot pressure)	**Apply** foot pressure on pedals

To engage the brake on the scooter, the opposite to natural reactions must occur. A scooter operator may have learned previously that on a bike you squeeze the lever to brake. The visual layout of handlebars and levers on a scooter is very similar to that of a bike, but if you squeeze the lever on the scooter you accelerate. And there lies a contradiction in the automatic action required.

Rear vision mirrors, indicators, the size and manoeuvrability and the layout of the controls give the scooter a sense of a vehicle-motorbike-bicycle.

Considering the design features, accessories and controls, what may the perception of the operator be? Where may the motorised scooter sit in the spectrum of mobility from the operator's perspective?

Mobility spectrum

Pedestrian el.wh/ch bicycle motorbike car
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2. The Human (the Operator)
Is the operator medically stable to use a scooter in the road environment?
Does the person have these abilities?
Physical hand function and upper limb strength; intact hand sensation

Sitting balance – static and dynamic ie can balance be maintained while moving/leaning
Head and neck movements to see to right, left
Visual scanning, ability to read signs and to see further than across the road
Ability to identify stationary and moving objects in the road environment

What are some of the cognitive and visual abilities demanded of one to operate a scooter?
Knowledge of road and pedestrian law; be adaptable and constantly problem solving,
Have attention, concentration to task; visual memory, recall
Ability to judge, plan, ahead, scan, identify and respond correctly to hazards
Ability to perform multiple task situations - to assess gradients, consider scooter stability, determine speed adjustments required, select gap in traffic and hence the safety of the manoeuvre required to reach a destination

Can the person complete the task of consistently operating the motorised scooter safely?
Is the person capable of learning new skills - to receive the information, retain it, recall and apply it at required opportunities?

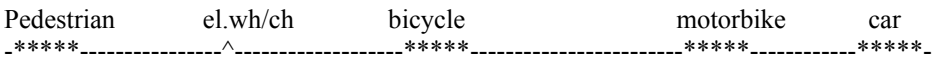
Has the person made the decision to surrender his/her licence, or has it been advised by the GP to discontinue driving?
What are their current transport options?
Are they able to access community transport alternatives to fulfil activities of their choice?
Is the scooter providing a "life changing" option ie reducing social isolation

What has been the previous experience and what roles did they fill in the road environment? - As a cyclist, motorbike rider, pedestrian, or driver of a car?
Is there evidence of issues with safety, risk-taking behaviour?
What were their habits and knowledge, fears and anxieties?
For example:
" When I am on the path I should act as a pedestrian" – (but I am quicker than a pedestrian),
" When I am on the road, I should act partly as a vehicle" - (but I am not quite as big).

I suggest that previous roles and experience may have strong influence on the motorised scooter users point of reference for their perceived position when in the traffic environment.

Where may the motorised scooter sit in the spectrum of mobility from the operators' perspective, when past experience, previous learnt behaviour, and past roles influence perceptions?

Mobility spectrum



Monitoring operator's health
With the ageing process, abilities change. With impairment, competencies maybe affected.
Cognitive change can affect the gaining of new knowledge and new skills, and the ability to judge.
In the sector of private ownership we are dependent on self-regulation amongst scooter owners. That is, owners need to recognise their changing medical fitness and competencies, and the possible impact of compromised pedestrian and road safety. The end point for the motorised scooter user is when they no longer have the necessary skills to operate the machine, to judge and problem solve the environment. Who decides this? After advice is given as to the unsuitability of the situation, who can ensure the motorised scooter is no longer used?

As with driving, there may come the time when the driver is no longer functionally competent to operate the vehicle in the environment. Licensing can deal with this. Often it is suggested that people then turn to the motorised scooter as their 'let down" option. Giving the scooter away therefore becomes a very large "cost" to their independence.

3. The Environment
Motorised scooters are used just about everywhere in the open community – on roads, footpaths, in car parks, across paddocks, on trains, buses. The built environment presents more accessibility barriers - in supported accommodation (hostels, nursing homes), public toilets, shops, service delivery buildings, recreational facilities, in supermarkets, malls.

There are building standards so that the built environment can be accessible to wheelchairs. But wheelchairs are very different in design and hence manoeuvrability. Motorised scooters are generally longer in wheelbase and

gross in steering. They continue to be built in increasing sizes. They do not always fit into the environments built under the wheelchair design standards for accessibility. And there lies an issue for the scooter operator. Some areas of the community open and closed may not accommodate them and they are then forced to become "less pedestrian and more vehicle"

Impact of design on manoeuvrability and accessibility in environment.
Due to the wheelbase dimension and that the turning wheels are front only, scooters require much more space for full lock manoeuvres and 3 point turns than does an electric wheelchair which can turn within its wheel base.
The impact is that the *turning circle* and manoeuvrability are compromised. It is not easy to manoeuvre closely and quickly toward and around road furniture. Many backward/forward movements are required. Some examples of this are at pedestrian mazes at railway crossings and when trying to reach pedestrian crossing buttons, when the scooter is on the ramp, and without having to alight the scooter. In tight areas where all curbs are not aligned or if they are poorly angled, it is frustrating and they are not always able to be the negotiated quickly. Consequently where does the operator need to go? Onto the road.

The *gradient, camber* and the condition of, or lack, of a footpath moves the scooter onto the road. The road is often a smoother and a more comfortable ride. The size of the scooter may cause the operator to move off the footpath when shared by pedestrians and gardens. Paths do not always provide the most direct and uncomplicated route – a road often does and will be followed. . Footpath repairs and underground maintenance work divert the walking pedestrian temporarily down the gutter and around to rejoin the path. The scooter may not have appropriate access, and may need to divert further within traffic

Short *pedestrian refuges* may not protect the long wheelbase scooter when used while crossing busy roads.
When entering or exiting a supermarket *car park*, there are often no direct and accessible paths and a minimal number of curb ramps to access the building. Shops place signs and objects on their section of pavement, which may become obstacles. The environment is built for vehicles. The scooter becomes more of a "vehicle" as it takes to the road.

The *overall size* of the motorised scooter (particularly the 4 wheeled model), and its associated need for space for manoeuvres, forces some operators onto the road as it is less frustrating to negotiate and is more immediately accessible.

These examples illustrate how the scooter moves, and at times may be forced, toward the car end of the spectrum for improved accessibility.

Where may the motorised scooter sit in the spectrum of mobility from the operator's perspective when negotiating the environment?

Mobility spectrum

Pedestrian	el.wh/ch	bicycle	motorbike	car
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At the point of purchase
Distributors and suppliers who sell motorised scooters vary greatly in the amount of information provided to the buyer.. Some will offer the printed operating instructions only and a demonstration on-site with short practice. General information on maintenance, where to drive it, and a home trial may also be offered. Others offer their product with many extras. These may include: listed user hints and ideas, information on road safety, the "dos and don'ts" (list of practical warnings when negotiating the environment), a checklist that the supplier has informed the buyer of how to operate the machine. Some suppliers also provide the publications referring to driver safety including "The South Australian Handbook For Older Drivers" – a publication referring to vehicle driving, not scooter driving.

Suppliers in the medical industry sell products and have the consumer informed of its safe operation and use.
What if the supplier suspects that the scooter is unsuitable and the consumer cannot manage? They may advise not to proceed with purchase if their client is displaying obvious practical operational problems. But suppliers are not trained to recognise medical fitness or cognitive impairment, or to assess complex functional ability.
The amount of information provided at time of purchase may be generous in some cases, minimal in others. How well does the consumer sort out, retain and recall, understand and interpret this information? What are the messages recalled, and therefore what is then the consumers' perception of where they should be in the road environment?

As a supplier stated (after providing information on road dos and don'ts)

"they (scooter operators) go out of here and they do what they want really- they go where they feel safe, like the road because they get abused by pedestrians when on the footpath. It is often smoother and even on the edge of the road and they think they have less chance of being backed over" (supplier from Company A).

These points are not criticisms of the effort made by the suppliers, as many cover their obligations, others provide that and more. However, it does illustrate the point that the buyers can commence their scootering careers with mixed messages in regard to where they should be in the road environment.

Where may the motorised scooter sit in the spectrum of mobility from as a new buyer's perspective?

Mobility spectrum

Pedestrian el.wh/ch bicycle motorbike car
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While reflecting on the issues presented regarding the Machine, the Human and the Environment, ask -
Where now may the motorised scooter sit in the spectrum of mobility from the operator's perspective?
I suggest that there are a number of interrelating factors which may impact on the motorised scooter user's perception, and therefore where they actually drive when in the road environment.. This may be best illustrated in Figure 2:

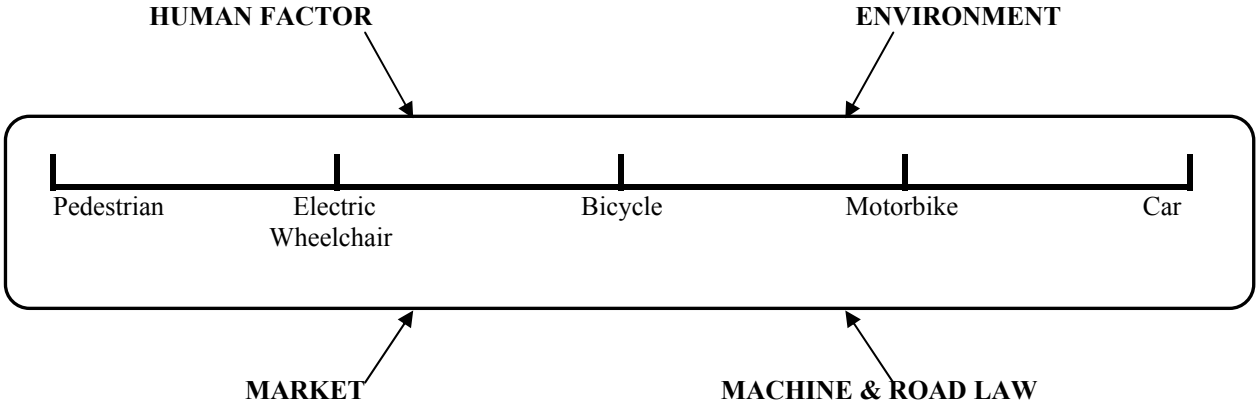

Figure 2: Factors influencing scooter user perception in mobility spectrum

The sum of the questions previously asked suggests that the scooter user may be positioned along the entire spectrum.
Mixed messages are in force.

Shifting perceptions
The question therefore needs to be asked - How then can the perception of the operator and hence action in the road environment be shifted toward being that of a pedestrian? Is training part of the answer?

Training in scooter operation
Human behaviour, such as cognitive function is a factor which impact on new learning in the operation of motorised scooter. It is about learning ability and opportunity to practise competencies and not just about being provided with information.

What is to be learnt?

1. Understanding of new subset of rules:
    - operation, pace
    - maintenance of scooter
    - position in the road environment, safety issues,
    - pedestrian etiquette and law
    - practical manoeuvring skills
    - recall and application of new information
    - unlearn previous habits/experience
    - problem solving the environment
    - skill checklist for operational competency

2. Opportunity to learn operating skills under all conditions off-road and on-road, familiarisation and practice, understanding safety issues and position in all areas of travel.

Correct prescription of the scooter helps to ensure a most suitable match of the operator (Human) to a particular model (Machine). Training – the joining of the machine, the human and the environment - is required before the evaluation of competency levels.

SUMMARY

The constant development in the design of the motorised scooter illustrates its changing role in a society which is demanding more mobility in lifestyle adjustment.

Where does the motorised scooter sit in the spectrum of mobility? Although it may be clear from the road authority point of view that the motorised scooter is considered pedestrian, it is suggested that there are many factors influencing the operator's understanding and practice of where the motorised scooter fits into the road environment. There are mixed messages which influence the perception of the operator. The end result has the motorised scooter caught between that of a wheelchair and that of a vehicle, with the operator moving between being a pedestrian and acting as a "vehicle" on the road, which is not always conducive to safe travel.

Safe and automatic action when operating a motorised scooter is dependent on the ability of the operator to undo past experience and learned reactions, and being able to retain new learned processes of operation. How and where does the scooter operator obtain clear consistent information in regard to the operation and safe practice when driving the scooter? Where is the opportunity to practise this knowledge?

Competency of the operator is evaluated on their knowledge, skill, problem- solving ability and an overall performance to negotiate the constant challenges presented when using a particular scooter in the environment. How is functional ability monitored in regard to safety and competency in scooter use with advancement of age or impairment in cognitive and or visual ability?

Who blows the whistle and how is a privately owned scooter removed when the operator demonstrates consistently unsafe skills in scooter performance due to functional changes? As we are dependent on self regulation of scootering ability, what is the safety risk that is placed on pedestrians and other road users?

CONCLUSION

In order to support the safe and competent use of motorised scooters, there is a need to address the issues and interrelationships of the human, the machine, and the environment. It is a community issue and the responsibility of operators, families, carers, GP, health workers, suppliers and engineers of machine and environments to collaborate to acknowledge, plan and act on the fact that the scooter is considered by road law a pedestrian device.

Further research, collaboration and system development for the management of motorised scooters and of the operators, is required. Collaboration with design engineers, health professionals and users is required to and keep the scooter design user- friendly and useful to this application. Existing systems should collaborate to address the practicalities of scooter use and reduce environmental barriers, to move toward improved safety in the pedestrian and road environment. Availability of practical training and performance evaluations with relevantly trained personnel may ensure consistent information to the operators. The effectiveness of such training programmes and the long-term outcomes need further research.

Collaboration in implementing systems to manage the outcomes of changing medical fitness and functional competencies in safe motorised scooter use may provide the basis in reducing pedestrian and road traffic risk.

Post Note

In South Australia, Scooter and Electric Wheelchair Working Party was formed in 2001. Health professionals are currently in the process of addressing the issue of medical fitness and functional competency for motorised scooter use. Other issues in scooter use are under discussion.

Since this paper was prepared:

- "Mobility Scooters User's Guide" handbook has been developed by DARS and Naomi Angove, School of Occupational Therapy, UniSA, Adelaide
- "Rehabilitation Council" has been recently formed for medical suppliers to determine standards and ethics for members. This will include addressing issues of customer service, equipment information, and training to customers.

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