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Review Article

Implementation of stroke care & road safety in India: Lessons from Australia

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India is home to one-fifth of the world's population and is currently the fastest-growing economy. As the health industry is growing, India needs to develop robust implementation of evidence-based health care addressing the major public health issues. Two of such issues India is grappling with are the establishment of stroke care and the reduction of road accidents. Australia has achieved notable success in implementing stroke care and reducing road accidents. In stroke, Australian initiatives include dedicated stroke units, the development of clinical guidelines, the implementation of acute interventions, the establishment of a national stroke foundation, and the stroke registry. As a result, the combined, primary, and secondary prevention measures, acute treatment, and rehabilitation have reduced the total disease burden of stroke from 2003 to 2023 by 53 per cent, from 7.4 to 3.5 Disability Adjusted Life Years (DALYS) per 1,000 population, which is a 56 per cent decline in fatal burden and 23 per cent decline in non-fatal burden. For road safety, Australia implemented evidence-based practices such as education, legislation including mandatory use of seat belts, and other road safety initiatives. Data show that seat belt use reached 98 per cent in Australia in 2023. Furthermore, about 20 per cent of drivers as well as passengers who were killed in crashes in 2024 did not wear seat belts. The reduction of speed limits in built-up areas, the adoption of monitoring technology, and the clever use of infrastructure are proving to be effective in reducing fatalities and serious injuries. Australia's implementation research can provide valuable insights into the efforts of mitigating the impact of stroke and enhancing road safety in India.

Key words Stroke care - road safety - implementation - India

India is currently the fastest-growing global economy and is home to one-fifth of the world's total population[1]. Given that the health of a population influences what can be achieved by a country's citizens of all ages, governments and health providers in India need to build a robust health system across a developing country where the health industry has grown at an annual rate of 22 per cent since 2016[2]. The country's current expenditure on healthcare, however, is still significantly below the global average of 10.89 per cent of total Gross Domestic Product (GDP) as of 2020[3]. Health expenditure per GDP during 1995-2017 in India was 3.7 per cent, with the main source of health related spending being out-of-pocket and is projected to increase to 4.1 per cent by 2030[4].

The low percentage of GDP spending, among other issues, means that underfunding is chronic, and staff shortages are severe at all levels. Medical supplies and medical staff are in short supply in government facilities due to which several individuals are forced to seek care from private providers, for which they must pay upfront. Recently, however, the Central Government launched the National Health Protection Mission (*Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana* or AB PM-JAY), which is financed by national taxes and allows low-income citizens to get advanced care at private facilities[5]. In addition, there is also health insurance dedicated to specific population groups, including government employees, factory workers *etc*[6].

The history of Australia's health system varies considerably from that of India, given Australia's shorter and less problematic geopolitical history, its small population, and its ability to make the most of its natural resources. In terms of GDP, Australia ranks seven places lower than India. However, while India's GDP per person is about US $2000, Australia's per person GDP is US $64,000, and the country spends a substantial portion of its national budget on healthcare for its citizens at 10.5 per cent of GDP[7]. Nevertheless, Australia, like India, suffers from underfunded hospitals, as well as critical shortages of material and medical personnel throughout the system.

Implementation of evidence-based healthcare

It is to note that at various stages in their overall economic and administrative development, India and Australia face similar issues in their healthcare sectors although different in degree. Humans worldwide are susceptible to serious non-communicable diseases (NCDs) like stroke, along with broad public health issues, such as accidental injury and death from road trauma. There is a goal in both Australia and India to maximize health outcomes as superior outcomes lessen government, individual, and community care burdens.

The desire to improve public health outcomes is evident in the well-established traditions of healthcare research, training, and collaboration that exist in Australia and India, with considerable emphasis on research translation into clinical practice. However, the non-adoption of evidence-based innovation has frustrated health researchers, leading to the development of implementation research, which is a design to study scientific methods for promoting a systematic uptake of research findings and/or other evidence-based practice into real-world settings by practitioners and policymakers[8,9].

In some instances, years-long efforts promoting the dissemination of research findings and persistently urging health administrators and personnel to amend or augment a healthcare practice have been successful. Strategies to inform, persuade or cajole the wider public into accepting, understanding, and adopting healthier behaviours have also resulted in several notable positive public health outcomes.

Two notable achievements in Australia's implementation efforts include advancements in stroke care and the mitigation of road accidents, both of which are issues India increasingly grapples with.

Stroke

As in Australia, the Indian population is ageing, and age brings with it a variety of disabling conditions, such as stroke. As per the United Nations Population Fund (UNFPA), the number of people ≥60 yr age projected increase in India from 149 million in 2022 to 347 million in 2050. By 2046, individuals over 60 will outnumber children up to 14 years of age. By 2050, one in five persons will be elderly[10]. The Australian population is ageing even faster. In only two years, more than 22 per cent of Australians will be aged over 65 yr up from 16 per cent in 2020, so the management of conditions associated with ageing, such as stroke, is critical[11].

Stroke ranks as the second most common cause of death[12], contributing to 50 per cent of cases of enduring disability[13]. The economic and emotional burden is expected to continue rising into the future. In India, stroke ranks as the fourth highest cause of death and the fifth highest cause of disability[14]. According to the Global Burden of Disease project in 2016, ~1,175,778 stroke incidents were estimated to have occurred in India. Recent systematic reviews, which included cross-sectional studies, indicated that the annual incidence of stroke in India varied from 105 to 152 cases per 100,000 individuals[15]. Nevertheless, there's a shortage of accessible data and inconsistency in methodologies across published research. One study conducted across four centres showed a mean age of 62.2 yr at the time of a stroke, which is younger than the global average, with one-fifth of strokes in India occurring under the age of 50 yr, demonstrating a need for further research into such anomalous results. The effects on the health,

finance, and welfare of the individuals and their families are generally devastating[16].

Stroke care in India: In 2010, the Government of India launched the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases & Stroke (NPCDCS). The programme aims to address early detection, treatment, healthcare infrastructure, public education, and skill development across different healthcare levels for all non-communicable diseases (NCDs), including stroke[17].

As the healthcare landscape evolves, addressing the specific needs of stroke care will contribute to better outcomes throughout the health system. However, there are many challenges to implementing stroke care in India, and Indian researchers have written about what needs to be done in various publications[18,19]. The barriers to managing stroke in India have been identified as including a lack of data and consistent methodologies in published research; poor surveillance and data collection; a lack of a well-defined stroke protocol, standard policies, and organizational support to provide evidence-based care; the lack of a policy framework; failure to control risk factors; a lack of public awareness; the late arrival of stroke victims to places of care; lack of adequate medical facilities and personnel; and a lack of rehabilitation services[15].

Stroke care in Australia: Australia has made considerable progress in stroke care since the early 2000s, with a concerted effort from healthcare professionals, policymakers, and advocacy groups. By embracing technology and prioritizing quality improvement, Australia has positioned itself as a global leader in stroke care. However, continued efforts are needed to ensure universal access, reduce disparities in care, and stay at the forefront of advances in stroke management[20].

Australia's success has been underpinned by research into the prevalence of stroke to demonstrate its impact on the care system and the community. Early initiatives (2000-2010) taken to improve stroke outcomes and care included the establishment of dedicated stroke units in hospitals, development of clinical guidelines, and the implementation of acute interventions. The impact of these initiatives has had significant effects on patient outcomes, as did the implementation of telemedicine for stroke diagnosis, management, and rehabilitation and the integration of technology into healthcare delivery[21].

The National Stroke Foundation (NSF), a national nonprofit organization collaborating with communities to prevent strokes, preserve lives, and improve recovery, advocates for stroke awareness, research, and policy changes (*https://strokefoundation.org.au*). The foundation conducts campaigns, educational programmes, and collaborative efforts with healthcare professionals to raise awareness about stroke symptoms, risk factors, and the importance of timely intervention[22]. Seven National Safety and Quality Health Service (NSQHS) Standards now strive to deliver a consistently high standard of care to consumers across the nation, ensuring access to quality services, effective treatments, compassionate support, and patient-centered care in all healthcare settings[23].

A person with a stroke is offered care and treated in a stroke unit in line with the Clinical Guidelines for Stroke Management, as enumerated in the National Acute Stroke Services Framework. Rehabilitation goals are assessed by trained staff within 24-48 h of admission and rehabilitation is started as soon as possible. Upon hospital discharge, an individualized care plan is supplied, and carers are provided with practical training as well as support to enable them to provide care and assist the patient. Innovation and a future direction for stroke care include the integration of artificial intelligence, personalized medicine, mobile stroke units, and other evolving models of care and measures of quality. The establishment of the Australian Stroke Clinical Registry in 2009 facilitated monitoring of the quality of stroke care prospectively[24].

In Australia, the combined, primary, and secondary prevention measures, acute treatment, and rehabilitation have reduced the total disease burden of stroke from 2003 to 2023 by 53 per cent, from 7.4 to 3.5 Disability Adjusted Life Years (DALYs) per 1,000 population, which is a 56 per cent decline in fatal burden and 23 per cent decline in non-fatal burden[25]. However, Australia is a large country, and the delivery of stroke prevention and management in remote areas, to its indigenous populations and other vulnerable groups continues to challenge the medical system. Innovative ideas, such as an Air-Mobile Stroke Unit (Air-MSU), have been proposed to bring stroke treatment to the patient, along with the development of novel diagnostic and imaging tools[26].

Road accidents: Road traffic accidents are the primary cause of mortality for individuals aged 5-29 yr globally, with over half of these fatalities involving vulnerable

road users like pedestrians, cyclists, and motorcyclists. These incidents impose a significant economic burden on most nations, amounting to 3 per cent of their GDP. The United Nations General Assembly (UNGA) has set an ambitious goal of reducing the worldwide number of deaths and injuries resulting from road traffic accidents by half by the year 2030[27].

Road safety in India: India, with its extensive road network and diverse traffic scenarios, faces significant challenges in reducing road accidents. A complex interplay of factors, such as traffic congestion, diverse road users, inadequate infrastructure, and varying enforcement levels contributes to a high incidence of road accidents. According to the Ministry of Road Transport and Highways, in 2020, there were over 450,000 reported road accidents, resulting in ~150,000 fatalities. While there has been a slight decrease in accidents compared to previous years, the numbers remain high[28].

Numerous factors contribute to the incidence of road accidents; many are behavioral. Speeding, reckless driving, driver fatigue, poor vehicle maintenance and lack of adherence to traffic rules are primary contributors to road trauma, with vulnerable road users, including pedestrians, two-wheeler riders and cyclists, being disproportionately affected by road accidents[29]. Operationally, inadequate road infrastructure is a major contributing factor to accidents. Roads are poorly designed and maintained. Visibility is poor and proper signage lacking. Investment in road infrastructure, such as dedicated cycling lanes, the development of safer intersections and traffic management systems, is essential, as is improving the emergency response, including well-equipped ambulances and efficient coordination between emergency services[30].

In India, inconsistent enforcement of traffic rules and regulations, along with corruption, are barriers to improving public safety. The number of law enforcement personnel is limited, and traffic control technology is under-utilized, which contributes to a culture of non-compliance among road users. Leveraging technology could significantly contribute to traffic management and accident prevention. The installation and effective use of traffic surveillance cameras and digital platforms for monitoring traffic, along with the reporting and recording of violations would enhance enforcement and road safety overall[31].

While high traffic density and congestion place heavy demands on traffic management in urban areas, rural road users must travel on poorly maintained roads with inadequate traffic control and limited access to emergency services. The data indicate that rural areas accounted for more than two-thirds of the fatalities in road accidents in 2022[32]. Addressing disparities between the urban and rural travelling experience requires context-specific interventions.

The Indian government has implemented several initiatives to address road safety. In 2007, the National Road Safety Policy[33] was adopted, and the Motor Vehicles (Amendment) Act of 2019 (MVA)[34] has improved road safety standards, enhanced penalties for traffic violations, and promoted the use of technology for better traffic management. The implementation of the Act has already resulted in a 'commendable reduction in the injury severity, violation of safety gears, alcohol use, and rash driving'[35].

Engaging communities in road safety initiatives is essential for sustained impact. Successful implementation of the provisions of the MVA encourages public awareness about road safety measures and the consequences of reckless driving. Educational campaigns, school programmes, and community engagement initiatives play a key role in fostering a culture of responsible road behaviour. Localized programmes, the involvement of community leaders, and collaboration with non-governmental organizations (NGO's) are beginning to pay dividends.

Road safety in Australia: Implementation research on road safety in Australia highlights the nation's commitment to evidence-based practices and continuous improvement in healthcare and public safety. Implementation studies have recorded the diverse strategies Australia has employed in the country's attempt to reduce vehicle-related injury and fatality. Implementation strategies over many decades have focussed on the five most common causes of road crashes in Australia including speeding, failure to wear a seat belt, intoxication (drugs and/or alcohol), driver fatigue and distraction.

In terms of combating road trauma, Australia has a tradition of trying to protect road users through education, as well as legislation. Various laws, policies, programmes, and education strategies have been put in place, for example, to reduce accidents and fatalities caused by speeding, which is a difficult behaviour to moderate in a human population. Although road safety structures, such as impact attenuators, crash cushions, median dividers, guardrails, and concrete barriers have

been put in place to protect vehicle occupants in a road crash, vehicle speed decreases their effectiveness.

The National Road Safety Strategy 2021-2030 stresses a movement and place approach which recognizes roads and streets serve dual functions as essential corridors for moving people and goods, and important public spaces where life unfolds[36]. In areas of high pedaestrian traffic or bicycle traffic, 40 km/h speed limits or lower are in place throughout Australia, and infrastructure is used to reduce speeds at points where vehicles must intersect one another or are traveling through residential areas, including roundabouts and speed bumps. The reduction of speed limits in built-up areas, the adoption of monitoring technology, and the clever use of infrastructure are proving to be effective in reducing fatalities and serious injuries[36].

As early as 1971, Australia emerged as the first country to legally bind compulsory seat belt use[37], and data show that seat belt use in 2023 had reached 98 per cent in Australia[38]. Approximately 20 per cent of drivers and passengers killed in crashes (where seat belt use is known) reportedly did not wear seat belts[39]. The fact that after 50 yr some Australians still fail to wear a seatbelt, although they are legislated, demonstrates why implementation research remains important.

Intoxication, driver fatigue, and distraction are well understood by researchers to be difficult factors to mitigate among the causes of road accidents. In terms of drivers who are intoxicated, Random Breath Testing (RBT) has been a cornerstone of Australia's efforts to reduce alcohol-related road crashes. A study by Home and Mcllwain[39] assessed the implementation and effectiveness of RBT programmes. This study highlighted the role of visible enforcement, public awareness campaigns, and legislative support in achieving high levels of compliance and reducing alcohol-impaired driving[40].

Driver fatigue or distraction is difficult to combat legislatively, although all Australian States and territories have strict mobile phone legislation in place making it a crime to use your mobile phone in a moving vehicle; for how do you turn the audio off or navigation only, unless it can be operated without touching it[41]. On the whole, however, combating driver fatigue and distraction requires psychological approaches involving road safety education in schools and information campaigns through media to instill safe behaviours in individuals. Another study by Oxley *et al*[42] explored the implementation of a comprehensive road safety education programme in Australian schools. The research results emphasized the need for a coordinated approach involving schools, parents, and communities to achieve sustained and positive effects on road safety knowledge as well as behaviour. Road safety initiatives such as these have been recorded to be successful in reducing road deaths from a peak in the year 1970 when 3,798 were recorded while in 2023, there were 1,266 recorded deaths[43]. However, this was an increase of 7.3 per cent from 2022, and progress has stalled, encouraging new implementation research[43].

Conclusions

After many decades, Australia has in place laws, programmes, policies, public and private groups, and community customs that assist in the management of public health issues, such as stroke and road safety. Nevertheless, the continued implementation of innovation in these areas of public interest requires persistent and strategic planning if gains in health and safety are to be maintained or enhanced. It is clear, on the other hand, that India understands what is required to improve the country's current stroke care and standard of road safety and, that research, planning, and preliminary action are underway throughout the subcontinent, although implementation of much good research faces significant barriers. Addressing this issue requires Government initiatives such as effective enforcement, infrastructure development, public awareness, technology integration coupled with community involvement, and a cultural shift towards permanent changes in human behaviour, all of which are vital for achieving success. Australia's implementation research can provide valuable insights into the efforts of mitigating the impact of stroke and enhancing road safety in India.

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