Research Article

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Retrospective analysis of the data concerning inspections of vehicles with adaptive devices

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Abstract: The article presents results of retrospective analysis of data from tests related to the diagnostics and inspections of vehicles as part of official technical tests carried out in 2016–2022, among the others, at the Automotive Service Centre for Disabled Persons operating at the Motor Transport Institute. The current trend shows that the quality of technical inspection is regularly improved by introducing legal standardization and standards for assessing the technical condition of a vehicle intended for a disabled driver. The subject of technical tests should therefore be adaptive devices designed to adapt the vehicle for their safe use by these people. As a part of this study, an analysis of the literature in the area of mobility and vehicle adaptation was also carried out, indicating the current directions of analyses and technical standards for adaptive devices.

Keywords: vehicle technical tests, disability, technical conditions, driver with a disability, adaptive devices, mobility, individual transport, professional activation

1 Introduction

In the European countries, a trend was observed related to improving the quality of compulsory technical inspections by introducing legal regulations on the method of assessing the technical condition of a vehicle.

These regulations define:

- test periods,
- attestation of roadworthiness,
- equipment used for testing vehicles and basic requirements,
- the level of knowledge and skills of diagnosticians,
- unifying the evaluated deficiencies and regulations,
- quality assurance of roadworthiness testing procedures through supervision within business entities (SKP – vehicle inspection station) [1,2].

For this purpose, the following regulations apply in Poland:

- Regulation of the Minister of Infrastructure of 15 December 2016 on the technical conditions of vehicles and the scope of their necessary equipment (Journal of Laws of 2016, item 2022, as later amended) [3],
- Regulation of the Minister of Transport, Construction and Maritime Economy of 10 June 2015 on the scope and method of carrying out technical tests of vehicles and templates of documents used in these tests (Journal of Laws of 2015, item 776, as later amended) [4],
- Admitting the vehicle into service (Act of 20 June 1997 – Road Traffic Law [Journal of Laws of 2022, item 988, as later amended]) [5],
- Technical conditions of the vehicle – (Article 66 of the Act of 20 June 1997 – Road Traffic Law [Journal of Laws of 2022, item 988, as later amended]) [5],
- Regulation of the Minister of Infrastructure and Construction of 11 December 2017 on the registration and marking of vehicles and the requirements for registration plates (Journal of Laws, item 2355, as later amended) [6],
- Regulation of the Minister of Infrastructure of 27 September 2003 on detailed actions of authorities in the matters related to the admitting a vehicle into service and model documents in these matters (Journal of Laws of 2019, item 2130, as later amended) [7],
- Regulation of the Minister of Digitization of 8 November 2017 on the scope of data made available in electronic form from the central register of vehicles (Journal of Laws of 2017, item 2085, as later amended) [8],
- Temporary withdrawal of vehicles from traffic – (Article 78a of the Act of 20 June 1997 – Road Traffic Law [Journal of Laws of 2022, item 988, as later amended]) [9].

National regulations reflect, among the others, the following European regulations:

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- Directive 2014/45/EU of the European Parliament and of the Council of 3 April 2014 on periodic roadworthiness tests for motor vehicles and their trailers and repealing Directive 2009/40/EC (Journal of Laws L127 of 29 April 2014) [10],
- Regulation (EU) 2018/858 of the European Parliament and of the Council of 30 May 2018 on the type-approval and market surveillance of motor vehicles and their trailers, as well as systems, components and separate technical units intended for such vehicles, and amending Regulation (EC) No. 715/2007 and (EC) No. 595/2009 and repealing Directive 2007/46/EC (Journal of Laws L151 of 14 June 2018) [11],
- Council Directive 1999/37/EC of 29 April 1999 on vehicle registration documents (Journal of Laws L138 of 1 June 1999) [12],
- Directive 2014/46/EU of the European Parliament and of the Council of 3 April 2014 amending Council Directive 1999/37/EC on vehicle registration documents (Journal of Laws L127 of 29 April 2014) [13],
- Directive 2014/47/EU of the European Parliament and of the Council of 3 April 2014 on the technical roadside inspection relating to the roadworthiness of commercial vehicles operating within the Union and repealing Directive 2000/30/EC (OJ L127, 29 April 2014) [14],
- Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheeled vehicles and quadricycles (Journal of Laws L60 of 2 March 2013) [15],
- Regulation (EU) No 167/2013 of the European Parliament and of the Council of 5 February 2013 on the type-approval and market surveillance of agricultural and forestry vehicles (Journal of Laws L60 of 2 March 2013) [16].

The subject of selecting technical conditions according to European standards should be the requirements for adaptive devices designed to adapt the vehicle in such a way as to enable safe driving of the vehicle by people with disabilities [17]. The technical conditions are used in the production, installation in a vehicle, testing and evaluation of adaptive devices [18]. A specific feature of vehicles properly adapted to be driven by disabled people is the scope of modifications tailored to the user, according to the professional recommendations of the occupational medicine physician with authorization to examine drivers. In the course of verifying tests, specific technical requirements should be applied in a manner that takes into account all external conditions [18]. Each use of the departure from technical conditions should absolutely be justified [17].

In Poland, there are regulations specifying the inspection of adaptive devices at the Office of Technical Inspection (UDT), e.g. lifts (Regulation of the Council of Ministers of 7 December 2012 on the types of technical devices subject to technical inspection – Journal of Laws of 2012, item 1468). This is the only group of devices that are subject to the diagnosis of functioning and suitability. The purpose of such a test is to confirm that the device can be put into safe operation. The acceptance test is performed by the UDT Inspector in the presence of the user operating the technical device.

The accelerator and brake controls (and others) are not under any inspection. Leaving the current state of legislative provisions may have an impact on the emergence of problematic situations that may threaten road safety, if the device is not "selected" in the right way (the right device for a person with a specific disability) and is not installed in accordance with the technical parameters. The only applicable provision in this case is: *"Art. 66. 1. A vehicle participating in the traffic is to be built, equipped and maintained in such a way so that operating it:*

1) does not endanger the safety of people driving it or other road users, does not violate the traffic order on the road and does not expose anyone to harm;

2) ensures a sufficient field of view of the driver and easy, comfortable and safe use of devices for steering, braking, signalling and lighting the road while observing it" (Act of 20 June 1997 – Road Traffic Law – Journal of Laws 1997 98, item 602, as later amended).

2 Review of the literature

In the work by Monacelli E., Dupin F., Dumas C., Wagstaff P., attention was drawn to the situation in which people with disabilities found themselves as far as the personal mobility in France was concerned. The authors presented the condition of people with motor disabilities, with particular emphasis on people in wheelchairs. The research on the basis of which the study was prepared indicated the division of people with disabilities with congenital disabilities and people with acquired disabilities. The further part of the article focuses on the statistics conducted in France in 2009, relating to the participation of people with disabilities in road accidents. For the purposes of the research, an analysis of the provisions of the legislation related to the mobility of people with disabilities was performed and a number of inaccuracies relating to the applicable legal provisions were identified.

The analysis performed was described in relation to the situation in the rest of European countries, reaching unambiguous conclusions that there is no standardization of legal provisions in the European Union, which would facilitate their unambiguous application and compliance. The authors also drew attention to the inconsistent methods of selecting adaptive devices to the type of disability and the lack of procedures enabling their proper selection. The conclusions indicate directions in which to develop new initiatives related to reliable evaluation procedures, the selection of equipment to the needs and abilities of the driver, type-approval of vehicles equipped with adaptive equipment and packages enabling financial support in the field of mobility of people with physical disabilities.

The work by Hutchinson et al. entitled "Modified motor vehicles: the experiences of drivers with disabilities" [19] addresses the topic of driving an adapted vehicle by drivers with disabilities. The authors drew attention to the heterogeneous approach of drivers with disabilities to the use of an adapted vehicle. The vehicle is used by them not only to overcome barriers while being mobile, but is also a target of active rehabilitation. The next stage of research work was to identify and describe the feelings that a disabled driver experiences while driving. For this, the authors used research conducted in the form of interviews with drivers. Based on their statements, four main premises were defined relating to: ease of movement, difficulties in using the instrumentation, assumptions regarding other means of transport in the absence of own means of transport and fear of the temporary loss of an adapted vehicle [20]. The Person–Environment–Occupation model was used to determine the above-mentioned conclusions, which served as an orientation framework to define the direction of the research. In the final conclusions it was emphasized that the conducted works, despite the small scale, underlined that the adapted vehicle could be used in a wider context. On the other hand, the fears of the surveyed drivers about losing the vehicle, difficulties in using adaptive equipment did not allow for the full use of the vehicle's capabilities. The main directions of the research method development should be the extension of the research sample, which will help to specify the feelings accompanying drivers with disabilities while driving. Additional factors taken into account during further works should be changes in environmental factors and the development of public infrastructure, e.g. an increasing number and location of adapted parking lots, driveways located near the entrances to the interior of buildings. An important convenience would also be the unification of procedures and standards related to the verification of the equipment used, e.g. regulations governing technical inspections and type-approval of vehicles equipped with equipment for a disabled driver.

In the work by Henriksson and Peters entitled "Safety and mobility of disabled people driving adapted cars" [21], the research was carried out focusing on the safety of drivers with disabilities. Work on the research problem was started with the use of a questionnaire that determined the type of driver's disability, adaptive equipment in the vehicle, road safety and participation in road incidents. The questionnaire was sent to a randomly selected sample of disabled drivers who were owners of adapted vehicles. The authors noticed that as a result of road accidents involving people with disabilities, 793 cases (30% of responses) were related to spinal cord injury. As a consequence, they were diagnosed with disability of the lower limbs, which resulted, among other things, in functional limitations in over 75% of diagnosed drivers. During further diagnosis, the researchers focused on verifying the level of safety and the feelings that accompany the handling of an adapted vehicle while driving. In response, high scores were obtained related to evaluating the sense of security and trust in the adapted vehicle. Such a high level of trust and convenience in the use of adaptive devices translated into driving in most situations in which disabled people had to use transport. Such a high level (90% of answers among respondents) may indicate a great need for mobility on their part. When assessing the safety of the instrumentation, the respondents indicated that during the last period, i.e. 3.5 years, they had participated in transport incidents, but the only losses that occurred were material losses. About one in ten drivers have been involved in an accident in the past 3.5 years, most of them only having material damage. Only in this case, problems with the installed adaptive devices were noted. The final conclusions show the directions of research development focusing on increasing the safety of using the adapted vehicle. The critical points of adaptation processes were also indicated, among them the lack of type-approval and diagnostic tests of vehicles adapted to the needs of disabled drivers [22]. The authors emphasized the essence and great need to develop the conducted research in order to ensure the highest possible level of safety for disabled drivers driving adapted vehicles [23].

In a research article by Hutchinson et al. entitled "Using social return on investment analysis to calculate the social impact of modified vehicles on people with disabilities" [24], the research was conducted on the role of a fully adapted vehicle in the professional activation of drivers with disabilities. The research was conducted in the form of a questionnaire. The method used

in the research was to enable the analysis of the return on invested funds in vehicle modifications. Drivers with inborn and acquired disabilities participated in the research. Occupational therapists, certifying doctors, driving instructors and adapters also participated in the qualitative interviews. A co-investment model was used for the research, allowing to estimate the return on investment costs for both the financing entity and the consumer. Five scenarios were developed, each to a different degree of costs involved, the first being low cost assumptions and the last being the most costly vehicle modifications. After analysing the results, it turned out that the social return on investment indicators used in the research were positive for investors and consumers. In the conclusions, the authors of the study emphasized the important role related to the use of the adapted vehicle in the social and professional activation of people with motor disabilities. The financial span related to the existing adaptive devices on the market has been highlighted. Safety issues related to adapted vehicles were also emphasized, as well as verification of the quality of the installed adaptive devices in relation to diagnostic tests.

The article "Disabled limbs need ergonomic assistive technologies and car modifications" [25], by Suliano et al. The article contains research materials on the needs of drivers with disabilities in the ergonomic design sector. The needs presented in the article resulted from the survey research. They related to the statements made by 30 randomly selected drivers with disabilities in 2020 in Selangor, Malaysia. The main purpose of the research was to verify and determine the real need to design a device that is convenient to use and enables safe and comfortable driving. A survey was conducted based on the previously collected statements of drivers with disabilities. During the research work, attention was paid to the evaluation of five aspects of ergonomics – safety, ease of use, comfort, productivity, efficiency and appearance. The Likert scale (from 1 to 5) next to each question was used to determine the value. Based on the collected responses, it was found that when designing adaptive devices, particular attention should be paid to the materials used to make the handle of the device and to improve the connections with the vehicle steering system. The authors emphasized the fact that devices intended for driving a vehicle by a driver with disabilities should be subject to ergonomic design. In the final conclusions, the authors emphasized that the adaptive device designed based on the above-mentioned indications should be further verified, among the others, by diagnostic tests. The article indicates further directions of research development.

The 2020 article by Kett et al. "Disability, mobility and transport [26] in low- and middle-income countries: a thematic overview" [27], highlighted the mobility needs of people with special needs. The authors emphasized how important a factor is the process of interconnecting disability with a number of other factors influencing the transport needs of people with special needs. The article emphasizes how important the role of the above-mentioned people is played by the possibility of free mobility, and thus the possibility of having and using their own means of transport [28]. The article aims to start a discussion related to the identification of the most important areas for further research related to the mobility needs of people with motor disabilities. Attention was also drawn to the need for equal treatment and to ensure the mobility of all people, regardless of their mobility and wealth. The authors verified the regulations governing the areas related to ensuring the best possible quality of transport services. In the review of legal acts, they indicated the shortcomings in this respect. They raised, among other things, the lack of type-approval test procedures and diagnostic tests of vehicles adapted to the needs of a disabled driver. The final conclusions contained indications relating to the deepening the issue of mobility of people with special needs in low- and middle-income countries. They also referred to the development of systems that make it possible to travel by various means of transport in a way that is widely accessible to all social groups.

3 Research methods

Paper questionnaires and e-questionnaires related to the mobility of people with disabilities were prepared for the research work. The study was carried out using a random selection of a research sample. For the above-mentioned process, databases containing a list of vehicle inspection stations were used. Some of the vehicle inspection stations used in the (survey) research are under the Patronage of the Motor Transport Institute, while the remainder were randomly selected SKP addresses. Among the surveyed respondents there were only professionally active diagnosticians employed at the above-mentioned vehicle inspection stations according to the distribution of participants presented in Diagram 1.

The set of feedback information was to contain data related to the time interval relating to the years 2016–2022. The tested feature was the awareness-trend of knowledge and the need for changes in legislation related to procedures including periodic inspections carried out at vehicle inspection stations in vehicles adapted to driving by a disabled driver [29].

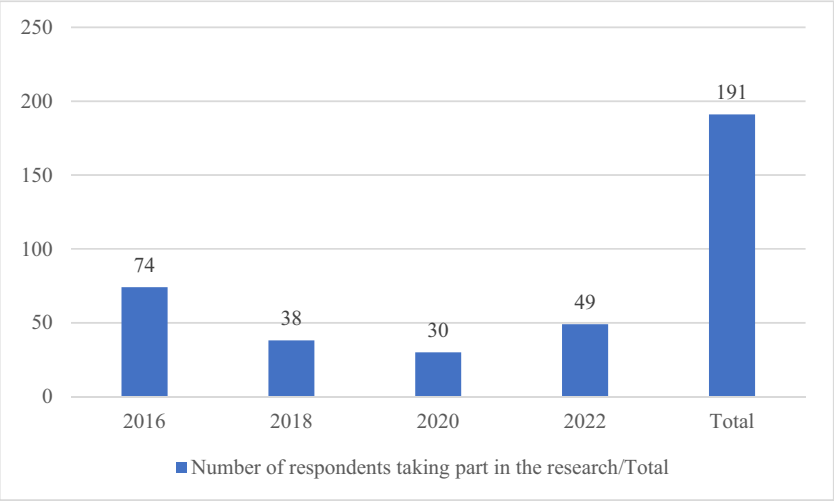

Diagram 1: Number of respondents.

The area of the research was deliberately limited to adaptive devices enabling the driving of a vehicle by a driver with a mobility deficit (tetraplegia and paraplegia) [30]. The range of self-driving devices is much more extensive than the one on which the research work was focused. Only the devices that are most commonly encountered while driving are deliberately described in the survey sheets. They were selected based on the interviews with drivers with various motor dysfunctions. Additionally, by deepening and narrowing down the group of adaptive devices, the previously collected opinions and statements of diagnosticians who work at the SKP were used. After verification of the results related to the statements on adaptation devices, the following were selected: hand throttle/brake, separate throttle and a separately mounted brake lever, all kinds of handles in the form of knobs enabling the steering wheel to be operated.

4 Research results and discussion

The presented results of the analysis of data from four questionnaire studies conducted by the Centre of Automotive Services for Disabled People operating at ITS and a student of the Military University of Technology (MUT), Mr Szymon Niekało [31] in the years 2016 [17], 2018, 2020 [31] and 2022, include the most important conclusions regarding this topic:

- knowledge of the legal regulation by diagnosticians of Vehicle Inspection Stations (SKP),
- knowledge of vehicle modifications carried out,
- vehicle diagnostics issues,
- adaptive devices available for drivers with disabilities,
- introducing compulsory roadworthiness tests for vehicles in the future following technical changes.

Retrospective data analysis in the research is presented in the form of the graphics below. The authors of the study asked the respondents about the existence of provisions regulating the installation of adaptive devices in vehicles (Diagram 2).

Recent years show that half of the respondents believe that there are regulations governing the installation of adaptive devices in vehicles of people with disabilities.

Then, the authors of the research asked whether in their professional practice they had encountered any

Diagram 2: Legal provisions regulating the use of adaptations in vehicles.

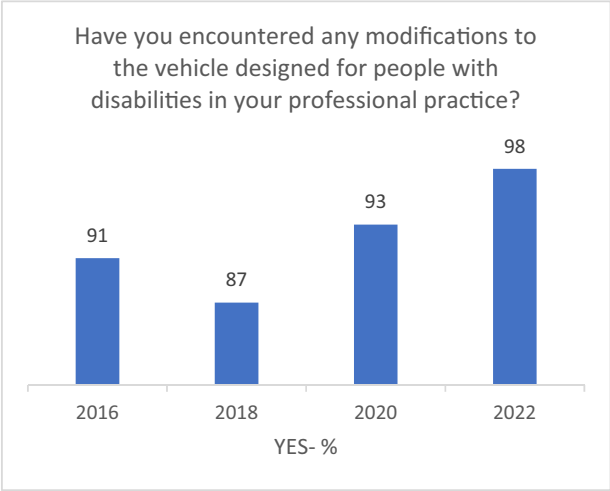

Diagram 3: Vehicle modification.

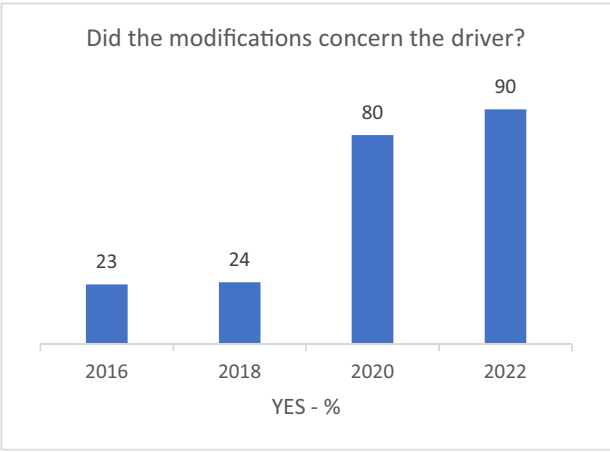

Diagram 4: Modification of the vehicle for the driver.

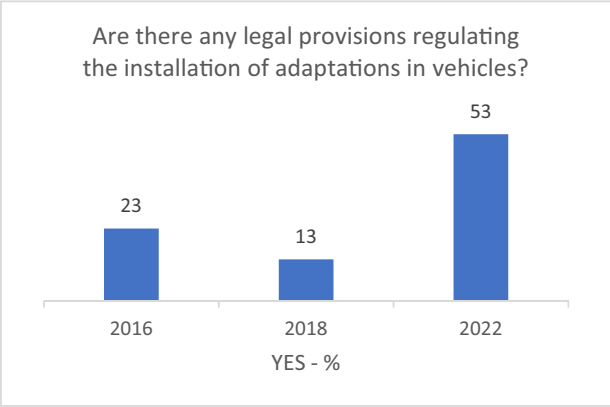

Diagram 5: Problems with the diagnostics of vehicles with adaptations.

modifications to vehicles intended for people with disabilities (Diagram 3).

According to the above results, most of the respondents indicate that in their professional practice they have encountered a modification of a vehicle intended for a disabled person.

They were also asked whether the modifications concerned the vehicle driver and whether there were any problems with the vehicle diagnostics (Diagrams 3–5).

The research has shown that since 2016, the share of vehicles with adaptive devices for drivers with disabilities in the road traffic has increased, and thus the problems with the diagnostics of these vehicles have increased.

Interesting results are presented in Diagram 6 presenting the different types of adaptive devices:

– manual operation of the acceleration pedal, brake, clutch, Figure 1,

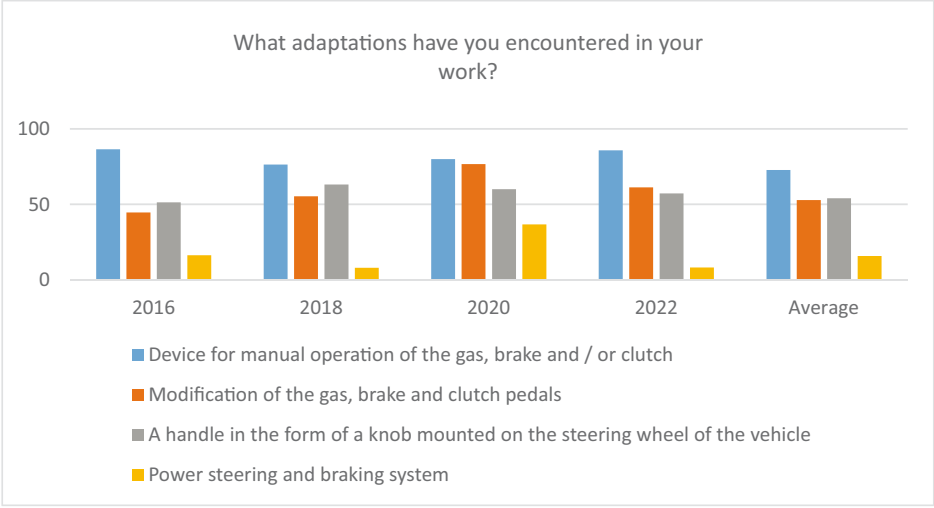

Diagram 6: Adaptive devices for the driver.

Figure 1: Pull–push device with accelerator lever. Source: ITS.

Figure 2: Handle in the form of a knob. Source: ITS.

- modification of accelerator, brake, Figure 1,
- using the knob on the steering wheel, Figure 2,
- power steering and braking system servo.

The largest group on the adaptation market are vehicles which, in all tests, had devices for manual gas [32], brake and clutch operation.

The survey used for research in 2022 was extended by two issues relating to the validity of the introduction of relevant regulations and performing mandatory periodic technical inspections after vehicle adaptation (Diagram 7).

Most of the respondents (92 and 84%) in both cases are definitely unanimous and believe that appropriate regulations should be applied governing the principles of using individual adaptive devices. A relatively small group of diagnosticians is against any changes to the regulations in this area (8 and 16%).

5 Summary

The presented material focuses on analysing the scope and possibility of conducting a periodic test of a vehicle adapted to the needs of people with disabilities. The first stage was to illustrate the area in which the research will be directed. In this regard, an analysis of the literature was carried out, taking into account the applicable regulations. Further efforts were directed to carry out innovative research with the use of questionnaire sheets. The research used a specially developed sheet in a paper form, which was used to deepen the research carried out in electronic form. Based on them 191 responses were obtained, collected in the period 2016–2022. After

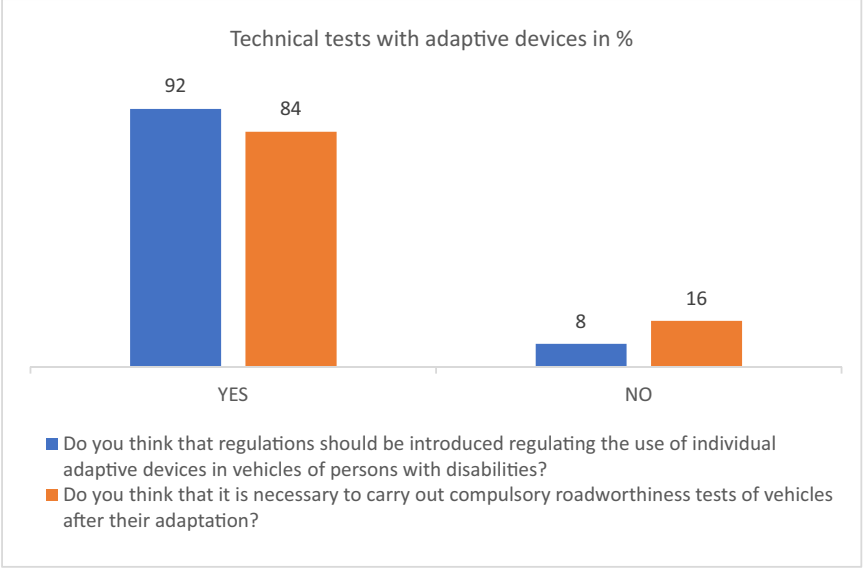

Diagram 7: Technical tests of vehicles with adaptive devices.

the completion of innovative research, in the form of a questionnaire [33], materials were collected that allow to conduct an analysis reflecting the state of knowledge and the instruments at the disposal of an authorized diagnostician during the periodic inspection of a vehicle adapted to transport and drive people with special needs. The analysis of the results is presented in a graphic form. On its basis, conclusions were drawn related to the deficiencies in the legislative provisions of test procedures.

The collected responses showed the direction in which the legislation should develop in order to provide all possible activities related to the verification of vehicles driving on public roads. The defined procedures should make it possible to carry out detailed tests related to vehicles adapted to the transport of passengers, with particular regard to adaptive devices installed inside the vehicle. In addition, the scope of periodic tests should be extended to include procedures that take into account the provisions on the verification of devices that enable a driver with disabilities to drive a vehicle. The analysis was based on the legal provisions in force in the years 2016–2022 in the field of periodic tests. Based on the collected materials and their analysis, shortcomings in the procedures covering the sector of the above-mentioned people with special needs were identified. The studies that have been carried out present only a part of the needs of the mobility sector of people with disabilities. It seems that it would be advisable to extend the presented research samples to other groups (partial movement disorders – paresis, paralysis of all parts). Continuation of the research in the described scope could increase the safety level of vehicles travelling on public roads and positively influence their technical condition. The proposed further steps should include the introduction of training for diagnosticians to familiarize themselves with the process of adapting vehicles intended for transporting and driving people with special needs. The use of a practical illustration of the issues related to the mobility of people with disabilities could positively influence the broadening knowledge of diagnosticians and affect the quality of the periodic examination.

Conflict of interest: Authors state no conflict of interest.

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