# Designing Parameter for Developing Standard of Manual Wheelchair

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**Abstract:** Indonesia already has national wheelchair standards namely Indonesian National Standard (SNI) SNI 09-4663-1998, but the standard already used for 20 years without any renewal. On the other hand, the development of wheelchair technology has a rapid transformation; wheelchair developers begin to apply the technology to their wheelchairs. For the development, relevant stakeholder are needs to identify key parameters for developing wheelchair standards. To develop this standard the Framework for Analysis, Comparison, and Testing of Standards (FACTS) method is used. The FACTS have three stages: analysis, comparison, and testing. The FACTS method is used to identify stakeholder needs. The results of this study is a framework that can be used to develop a wheelchair standard. It is also proposed a structural equation model for measuring implementation standard and we can classify them into three dimensions, *i.e.* improve quality, stakeholder protection and smothness and efficiency of trade.

## 1. Introduction

Nowadays, health equipment industry growing rapidly. The government also tries to develop it, one of it is wheelchair. Wheelchair is one of the health equipment products and which can be developed by the domestic industry. The development of wheelchairs growth in various aspects, especially on aspects of technology [1]. There is a greater demand on wheelchairs for the elderly [2]. In Indonesia at this time the number of wheelchair needs is quite large, but the domestic industry not able to fulfill demand of wheelchairs.

Indonesia does have the standard about the wheelchair, which is Indonesian National Standard (SNI) - SNI 09-4663-1998. This wheelchair SNI has been established since 1998 and has been used for almost 20 years without any renewal. On the other hand, the development of wheelchair technology has a rapid transformation, wheelchair developers begin to apply the technology to their wheelchairs. Therefore, it is necessary to review the existing wheelchair standard and work to improve the standards and make sure that they serve their purpose of assuring quality, providing a foundation for evidence-based data; promoting optimal matching of user and wheelchair; and ensuring safe and productive long-term use [3]. Using standards to improve mobility devices can increase wheelchair reliability and reduce risks to end-users [4]. The approach chosen to develop the standard is FACTS. We were used the FACT approach to develop the standard electric

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vehicles in Indonesia, i.e. the cell, modules, and BMS standards [5-7]. This FACTS approach better suited to the needs because can be applied at every standard life cycle stage. The FACTS approach considers the interests of all relevant stakeholders, so the principle of consensus in standardization is to provide an opportunity for those with an interest to express their views to be accommodated. Then, this approach also provides the Framework for analyzing, comparing and testing standards by structuring and formalizing information by Zachman framework. Furthermore, in the development of standards, we need to know how the effect of standardization for commercialization and innovation of wheelchair products, for that Structural Equation Modelling (SEM) is an approach that can use for calculate the effect and the SEM calculations are performed to identify the national differences of the standard.

## 2. Research method

The FACTS (a Framework for Analysis, Comparison, and Testing of Standards) is a methodology developed by NIST (National Institute of Standards and Technology, US Department of Commerce) that can be used to develop and implement standards [8]. The FACTS consider all interests of all relevant stakeholders, this approach also provides a framework for analysing analyzing, comparing and testing standards by structuring and formalizing information through the Zachman Framework. Zachman Framework is a framework used to obtain information using 5W+1H questions, namely: What, How, When, Who, Where, and Why. This FACTS approach can be applied at every standard life cycle stage that is standard development; standard implementation; and standard maintenance.

The SEM is a statistical analysis tool that can explain the relationship between variables with manifest variables, and also can know the relationship between latent variables by calculating errors that will always exist in each calculation [9]. The SEM used to explain relations between variables that exist in research. Not just for models, but to observe and satisfy models. Therefore, the main requirement of using SEM is building models that consist of models and models in the form of diagrams. The SEM is a set of possible statistical techniques. The relationship builds between one or more independent variables. The SEM was applied to simultaneously examine the model and hypothesized relationships proposed in the study [10]. Next, it is necessary to make the draft of Indonesian National Standard (RSNI) for manual wheelchair with national defferences.

## 3. Result and discussion

### 3.1. Stakeholder analysis

In the development of standards, an analysis of standards needs to be required to accommodate all stakeholder needs related to standards. Quality requirements and standard parameters from stakeholders are essential for the development of standards. There are 3 main parameters to develop wheelchair that is functional performance, seating and postural support, and strength, durability, and safety. The parameters collected are used for the base to make the questionnaire are shown in Table 1.

From the design of the questionnaires, data will be collected using purposive sampling. Respondents filled out questionnaires with scores of 1 to 5, and 1 indicating strongly disagree to 5 indicating strongly agree. The respondents of this research are all the stakeholder of wheelchairs. Stakeholders involved are governments, producers, consumers. Based on focus group discussion obtained respondents who represent relevant stakeholders that shown in Table 2.

Table 1. Questionnaires design.

| Dimension | Variable | Attribute | References |
|---|---|---|---|
| Functional Performance | Stability | Static Stability | [11], [12] |
| | | Dynamic Stability | [11] |
| | Transporting Wheelchair | Easy to move from & to the wheelchair | [11] |
| | | The ease of carrying a wheelchair | [11] |
| | Maneuvering | Maneuvering around obstacles (limited space) | [11] |
| | | Maneuvers over obstacles | [11] |
| | Additional Function | Energy efficiency | [11] |
| | | Ease of repair / acquire components | [11] |
| Seating and Postural Support | Dimension | Maximum Length | [13] |
| | | Wide | [13] |
| | | Total Height | [13] |
| | | Chair Height | [13] |
| | | Seating Width | [14] |
| | | High seat from Land | [13] |
| | | High armrests from the seats | [13] |
| | | The length of the seat | [14] |
| | | Backrest Height | [13] |
| | | Maximum weight of a wheelchair | [13] |
| | | Adjust the anthropometry of Indonesian people | [15] |
| | Mounting | Type of Chair | [11] |
| | | Chair cushion | [11] |
| | | Material chair | [11] |
| | | Seat cushion material | [11] |
| | Adjustable and Ergonomic Factor | Backrest | [11], [16] |
| | | Footrest | [11], [16] |
| | | Armrest | [11], [16] |
| | | Rear wheels | [11], [16] |
| | | Push Handle | [11], [16] |
| Strength, Durability, and Safety | Sturdy Design | Assembly with electric welding | [15] |
| | | Folding footrest | [11], [16] |
| | | Strong footrests | [11], [16] |
| | | Strong in maximum load usage | [11], [16] |
| | | Strong in normal use | [11], [6] |
| | | Not damaged when it falls | [11], [16] |
| | | There is no surface plastic deformation | [16] |
| | | No component cracks | [16] |
| | Hard Material | Hard frame material | [11] |
| | Durability | Durable chair frames | [11], [16] |
| | | Push Handle | [11], [16] |
| | Flammability | Not flammable | [11], [10] |
| | | Corrosion Resistant | [17] |
| | Safety of Surface | Flat surface | [11] |
| | | Cover tires | [18] |
| | Brake Effectiveness | Has a reflective sticker | [11] |
| | | Stop on a derivative path | [19], [11] |
| | | Not unexpectedly suddenly | [19], [11] |

Table 2. List of relevant stakeholder.

| Producers | Consumer | Government |
|---|---|---|
| **PT. Mega Andalan Kalasan** (www.mak-techno.com/id/) | **YPAC Jakarta** (www.ypacjakarta.org/) | **BSN** (www.bsn.go.id/) |
| **PT. Darma Medipro** (www.medipro.id/) | **YAKKUM** (www.yakkum.or.id/) | **KAN** (www.kan.or.id/) |
| PT. Shima Prima Utama (www.shima-indonesia.com/) | **RSUD Solo** (www.rsmoewardi.com/) | **Kemenperin** (www.kemenperin.go.id/) |
| **PT. Tesena Inovindo** (www.tesena.co.id/) | **BBRSBD Surakarta** (https://www.kemsos.go.id/content/bbrsbd-surakarta) | **Kemendag** (www.kemendag.go.id/) |
| **CV. Nuritek Indonesia** (www.nuritek.tripod.com/) | | **Kemenkes** (www.kemenkes.go.id/) |
| **PT. Pharmindo** (pariko-ina.com/) | | |
| **PT. Asiatechnik Utama** (https://pt-asiatechnik-utama.indonetwork.co.id/) | | |
| **PT. Farrindo** (https://farrindonusantara.indonetwork.co.id/) | | |
| **PT. Sani Tiara Prima** (www.sani.co.id/) | | |
| **CV. Bartec** (https://bartec.id/) | | |

### 3.2. Technical analysis

Technical analysis is used to transform stakeholder requirements into technical requirement using Zachman Framework, through the basic question 5W + 1H (What, How, When, Who, Where, Why). The following is a basic question that is used to interpret stakeholder needs into technical needs: (i) What: What specifications are required by stakeholders in the development of wheelchair products? (ii) How: How to measure/test the specification? (iii) When: When is the measurement/testing done? (iv) Where: Where is the measurement/testing performed? (v) Who: Who made the measurement/testing? and (vi) Why: Why is the measurement/testing necessary?

### 3.3. Comparison standard

In this section, the standard comparison is used to identify standard gaps and overlaps. Standard comparisons are made through informal approaches, typology and case applications. The standards comparable are national and international standards related to wheelchairs. Through standard comparison then known what standard that fulfills the needs or technical aspects. Technical requirement and comparison standard are shown in Table 3.

### 3.4. Testing standard

Testing standards are used to test whether the standard formulated can be accepted by consensus. In this phase, the defined standard framework will be verified and validated. Verification is carried out to determine whether the standard has maintained all the needs of relevant stakeholders and fulfilling national differences. The process of verification and validation on Focus Group

Disscussion (FGD) and survey with questionnaire interested stakeholders appointed directly by the National Standardization Agency (BSN). While validation is done to know the ability of current stakeholders to fulfill the requirements/matters issued in the manufacture of the standard.

Table 3. Technical requirements and comparison of referenced standard.

| Requirement | ISO 7176 | SNI 09-4663-1998 |
|---|---|---|
| Static Stability | ISO 7176-1 | Stated |
| Dynamic Stability | ISO 7176-2 | Not Stated |
| Easy to move from & to wheelchair | Not Stated | Not Stated |
| The ease of carrying a wheelchair | Not Stated | Stated |
| Maneuver around obstacles (limited space) | ISO 7176-5 | Not Stated |
| Maneuvers over obstacles | ISO 7176-5 | Not Stated |
| Energy efficiency | Not Stated | Not Stated |
| Ease of repair / acquire components | Not Stated | Not Stated |
| Maximum Length | ISO 7176-5 | Not Stated |
| Wide | ISO 7176-5 | Not Stated |
| Total Height | ISO 7176-5 | Not Stated |
| Chair Height | ISO 7176-5 | Not Stated |
| Seating Width | ISO 7176-5 | Not Stated |
| High seat from Land | ISO 7176-5 | Not Stated |
| High armrests from the seats | ISO 7176-5 | Not Stated |
| The length of the seat | ISO 7176-5 | Not Stated |
| High backrest | ISO 7176-5 | Not Stated |
| Maximum weight of a wheelchair | ISO 7176-5 | Not Stated |
| Adjust the anthropometry of Indonesian people | Not Stated | Not Stated |
| Type of Chair | Not Stated | Not Stated |
| Chair cushion | Not Stated | Not Stated |
| Material chair | Not Stated | Not Stated |
| Seat cushion material | Not Stated | Not Stated |
| Backrest | ISO 7176-8 | Not Stated |
| Footrest | ISO 7176-8 | Not Stated |
| Armrest | ISO 7176-8 | Not Stated |
| Rear wheels | ISO 7176-8 | Not Stated |
| Push Handle | ISO 7176-8 | Not Stated |
| Strong in normal use | ISO 7176-8 | Not Stated |
| Not damaged when it falls | ISO 7176-8 | Stated |
| No component cracks | ISO 7176-8 | Stated |
| Durable chair frames | ISO 7176-8 | Not Stated |
| Not flammable | ISO 7176-16 | Not Stated |
| Corrosion Resistant | Not Stated | Not Stated |
| Stop on a derivative path | ISO 7176-3 | Not Stated |
| Not unexpectedly suddenly | ISO 7176-3 | Not Stated |

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### 3.5. Structural equation modeling

The SEM calculations are performed to identify the national differences of the standard that can be useful to protect stakeholders, improve commercialization of domestic products and can be used as a protector product. The latent variable is a variable that is not directly measurable and forces the manifest variable or indicator for the latent variable to be measured and the manifest variable called a measurable variable. The latent variable in this study is an implementation of the standard with national differences with the main purpose of protecting the consumer, protecting stakeholders and protecting the wheelchair product. While the manifest variable is a technical specification of wheelchair standard that can measure how an implementation of the standard can accomplish the purpose of standardization. Proposed Structural Equation Model for measuring implementation of manual wheelchair standard are shown in Figure 1.
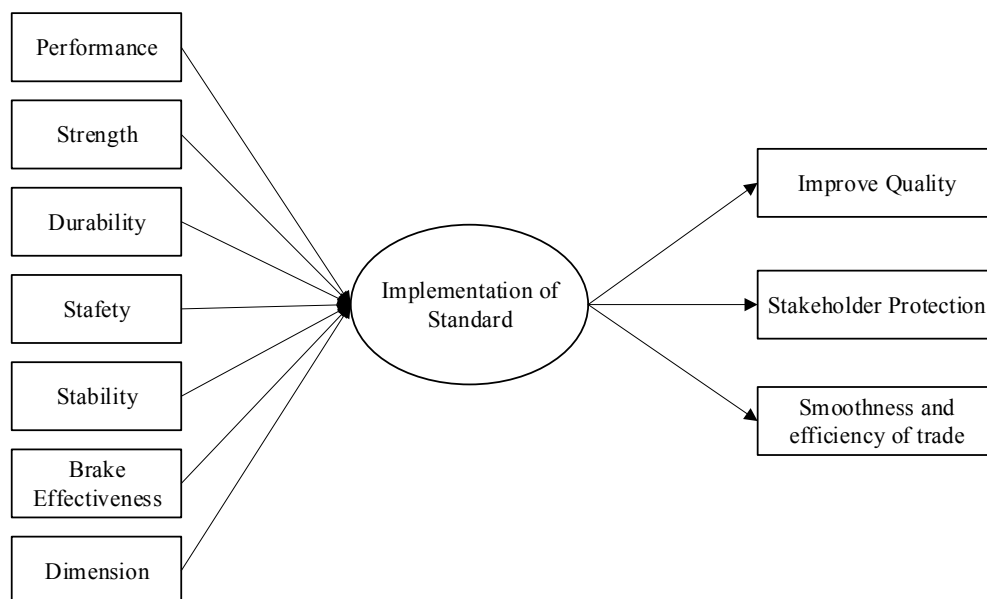


**Figure 1.** Model structure of a structural equation model for measuring implementation standard.

### 4. Conclusion

This study provides recommendations for the framework of the wheelchair standard. Based on the FACT approach, it can be concluded that developing the standard wheelchair has at least three main parameters, namely functional performance, seating and postural support, and strength, durability, & safety. The parameters are expected to strengthen the development of wheelchair. In addition, the SEM model used is also expected to perform to the national differences of the standard that can be useful to protect stakeholders, improve commercialization of domestic products and can be used as a protector product.

### Acknowledgement

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