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# Exploratory Factor Analysis for Developing Wheelchairs for Children with Cerebral Palsy

## Analisis Faktor Eksploratori untuk Pengembangan Kursi Roda untuk Anak Cerebral Palsy

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### Abstract

A wheelchair is an essential mobility tool for individuals with limitations, including children with Cerebral Palsy (CP). Cerebral palsy affects children under five and causes stiffness in various body parts. The design of wheelchairs for children with CP differs significantly from standard wheelchairs, prompting this research to identify the key factors that should be considered in designing such wheelchairs. This study used exploratory factor analysis, data was gathered from children with CP and their caregivers in Java. The findings revealed six fundamental factors to consider when designing wheelchairs for children with CP: Main features, Ultimate comfort, standard compliance, robust durability, thoughtful ergonomics, unique special features, user-friendly design, and aesthetic appeal. In summary, while the main features are crucial in the design of wheelchairs for children with CP, it is equally important that these wheelchairs comply with applicable standards and incorporate special features tailored specifically for these young users.

***Keywords:*** wheelchairs, cerebral palsy, exploratory factor analysis, product design.

***SDGs*:**


### Abstrak

Kursi roda adalah alat bantu untuk melakukan perpindahan bagi orang-orang yang memiliki keterbatasan, salah satunya untuk anak dengan Cerebral Palsy (CP). Cerebral palsy diderita oleh anak-anak usia balita, yang menyebabkan kekakuan pada bagian tubuh. Desain kursi roda untuk anak dengan CP berbeda dengan kursi roda pada umumnya, maka penelitian ini dibuat untuk mengetahui faktor kebutuhan dalam perancangan kursi roda untuk anak dengan CP. Metode penelitian ini menggunakan Analisis Faktor Eksploratori, pengambilan data dilakukan kepada anak penyandang CP dan orang tua atau pengasuh penyandang CP di Pulau Jawa. Hasil penelitian ini terdapat enam faktor kebutuhan dasar dalam perancangan kursi roda untuk anak CP yaitu Fitur Utama, Kenyamanan, Kesesuaian dengan Standar, Bahan Kuat, Ergonomis, Fitur Khusus, Kemudahan Penggunaan, dan Desain. Tidak hanya fitur utama yang penting dalam perancangan kursi roda untuk anak CP tetapi kursi roda juga harus memenuhi standar dan fitur khusus untuk anak CP perlu ditambahkan pengembangan kursi roda untuk anak CP.

***Kata Kunci:*** kursi roda, cerebral palsy, analisis faktor, desain produk.

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## 1. INTRODUCTION

Cerebral Palsy (CP) is known as a disease that causes impaired neuromotor function, so a person with CP experiences difficulties in movement, hearing, vision, learning, and thinking (Llontop *et al.*, 2020). In Indonesia, the prevalence of CP was 1 until 5/1000 live births (Tanjung and Sinaga, 2022) there are four different types of CP: Spastic (around 80% of all cases), dyskinetic, ataxic, hypotonic, and mixed. The Spastic CP is present at birth or in infant age (Levitt and Addison, 2018). Children with CP have less physical activity compared to other typical children (Goodlich *et al.*, 2020), thus condition will negatively impact their musculoskeletal development, and if the condition becomes a lifestyle in the future will become a disease such as obesity and cardiovascular (Maher *et al.*, 2007; Carlon *et al.*, 2013). On the other hand, children with CP need to access the hospital often, to go through their therapy, so a medical device to support their mobility is important. Hence, a Wheelchair is one of the medical devices commonly used for mobility.

Wheelchair for CP is different from the general wheelchair, some functions needed to add to accommodate the need of CP person especially in children, due to different anthropometrics from adult (Ekiz *et al.*, 2017). From the previous study, some factors have influenced to design of wheelchairs, seating arrangements can improve arm and hand function, and the goal is to achieve an upright forward-facing position by using padding, structured chairs, straps, or restraints to hold the body in a stable, safe, and comfortable manner (Zupan and Jenko, 2012). On the other hand, a wheelchair with an adjustable headrest, adjustable armrest, push handle, safety belt, joystick for wheel and brake, adjustable footrest, and folding frame is proposed for wheelchair for Children with CP (Kharisma and Indrojarwo, 2017). In contrast manual wheelchair with push more safety than power wheelchair independently (Rodby-Bousquet *et al.*, 2016). But another factor didn't have declared in designing a wheelchair for children with CP.

The research studies above provide the design of the wheelchair for children with CP. however, most of these studies focus primarily on the features that must be included in the wheelchair with CP, while studies on other factors in designing the wheelchair for children with CP are still lacking. This research aim is to investigate the need factor for designing a wheelchair for children with CP using Exploratory Factor Analysis (EFA) method. The usefulness of exploratory factor analysis (EFA) is well-established, particularly for its psychometric value in estimating the construct validity of various measurement instruments. EFA serves as a robust method for identifying underlying variables that contribute to broader theoretical constructs, aiding in the explanation of diverse measurement objects within the social sciences. By uncovering these hidden dimensions, EFA enhances our understanding of complex phenomena, allowing researchers to refine their measurement approaches and develop more nuanced theoretical models. This makes EFA a crucial tool for those aiming to rigorously analyze and interpret social science data (Ordóñez *et al.*, 2021). It is expected that the use of EFA in this study result can provide another factor that is needed for designing a wheelchair for children with CP.

## 2. METHODOLOGY

This study is quantitative research that uses instruments. The instrument provides the needed variables for the development of a wheelchair for CP, A questionnaire survey is effective to acknowledge the customer needs. The questionnaire was created based on a literature review concerning the development of wheelchairs and interaction with stakeholders. The selected respondent specializes in developing wheelchairs for children, which have in range aged five to eighteen years (Mboi, 2014). This targeted focus ensures that the needs of this age group are effectively met. The questionnaire was distributed online to the target areas, mainly in Java.

The questionnaire is built in two sections. The first section gathers demographic information about the respondent, including their name, age, gender, weight, height, and contact number.

**Table 1.** Questionnaire instrument.

| Indicators | Item Number | References |
|---|---|---|
| The use of a wheelchair is necessary to support your daily activities | no_1 | (Pratiwi *et al.*, 2019) |
| A wheelchair must fit your posture | no_2 | (Mardiana, Pujianto and Sulistyo, 2020) |
| A wheelchair must have comfortable seat cushions, backrests, footrests and armrests | no_3 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must have a backrest that can be adjusted according to your needs | no_4 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must have an adjustable headrest to suit your needs | no_5 | (Kharisma and Indrojarwo, 2017) |
| A body support is needed on the right and left side of the wheelchair | no_6 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must have adjustable footstep | no_7 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must have comfortable and adjustable footrests | no_8 | (Kharisma and Indrojarwo, 2017) |
| You are concerned about the high level of safety in wheelchairs | no_9 | (Pradita, Priadythama and Susmartini, 2018) |
| You are prioritizing a wheelchair with a high level of comfort | no_10 | (Pratiwi *et al.*, 2019) |
| You are very concerned about the convenience of using a wheelchair, such as being easy to operate, easy to move around, and able to overcome obstacles. | no_11 | (Pratiwi *et al.*, 2019) |
| A wheelchair must be equipped with a seat belt | no_12 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must be equipped with a strong stopper. | no_13 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair must be equipped with a frame that is strong and able to withstand the load | no_14 | (Pratiwi *et al.*, 2019) |
| A wheelchair must be stable when in use | no_15 | (Pratiwi *et al.*, 2019) |
| You are very concerned about the durability of the wheelchair, such as non-flammable and non-corrosive | no_16 | (Pratiwi *et al.*, 2019) |
| You are very concerned about the durability of the wheelchair, such as not being damaged in a fall and components that are not easily damaged | no_17 | (Pratiwi *et al.*, 2019) |
| A wheelchair can be folded and compact when not in use | no_18 | (Kharisma and Indrojarwo, 2017) |
| A wheelchair should be lightweight | no_19 | (Pratiwi *et al.*, 2019) |
| A wheelchair must be standard and certified by SNI | no_20 | (Pradita, Priadythama and Susmartini, 2018) |
| You are very concerned about the design of the wheelchair, as it should be attractive, colourful and patterned | no_21 | (Kharisma and Indrojarwo, 2017; Pratiwi *et al.*, 2019) |
| A wheelchair must have additional functions such as a folding table or luggage bag | no_22 | (Kharisma and Indrojarwo, 2017; Pratiwi *et al.*, 2019) |
| A wheelchair should be easily accessible | no_23 | (Kharisma and Indrojarwo, 2017; Pratiwi *et al.*, 2019) |

The second section contains questions regarding the need for a wheelchair, using a 5-point Likert scale, with a range of 1=strongly disagree to 5=strongly agree. The respondent is asked to rate each statement. The questionnaire consisted of 23 questions, as seen in Table 1. The data taken

from the respondent is treated with Exploratory Factor Analysis (EFA), EFA is the statistical multivariate technique to determine the factor or factor loading of the variables, the variables which have the same basic will be gathered in the same factor (McNeish, 2017).

## 3. RESULTS AND DISCUSSION

### 3.1. Concrete Assumptions in Exploratory Factor Analysis (EFA)

To ensure the data are valid for the test, several assumptions in the EFA must be met (Zakiyah, Setiawan and Rosnawati, 2022). The value of Kaiser-Meyer-Olkin (KMO) and Bartlett Test of Sphericity are used to test the correlation between the variables, the correlation must exist at least between variables. As seen in Table 2, the KMO value is 0.704 (above 0.5) and the value of significance is 0.000 (below <0.5) it is indicated that the samples are adequate for factoring and analysis can be done (Malik, Kamran and Sarfraz, 2022). The value of Measure of Sampling Adequacy (MSA) from all variables is above 0.5 indicating that variables can be used for analysis.

**Table 2.** KMO and Bartlett Test of Sphericity.

| | | |
|---|---|---|
| **Kaiser-Meyer-Olkin Measure of Sampling Adequacy.** | | .704 |
| **Bartlett's Test of Sphericity** | Approx. Chi-Square | 2053.742 |
| | df | 253 |
| | Sig. | .000 |

### 3.2. Extracted Factor

The amount of factor that formed can be determined from the value of Eigen Value, which has the value >1. From 31 variables, 6 factors were formed, with the Eigen Value >1 shown in Table 3. The number of variances that can be explained in the factor 1 until factor 6 showed in Table 3. The total variance explained by the factoring results is 71.341%. The numbers indicate that only the rotated and extracted values are important for interpretation (Yong and Pearce, 2013).

The Next step is extracting variables on some factors using Principal Component Analysis (PCA). This method groups variables with variances value that can be divided with other variances. After doing PCA, then do factor rotation to ensure the correct factoring results. Rotation factor using the Varimax method, by doing an Orthogonal rotation which rotates the axis 90°. The results of PCA and rotation can be seen in Table 4.

**Table 3.** Eigenvalues and total variance explained.

| Component | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % |
| 1 | 7.957 | 34.596 | 34.596 | 7.957 | 34.596 | 34.596 |
| 2 | 2.495 | 10.848 | 45.444 | 2.495 | 10.848 | 45.444 |
| 3 | 2.155 | 9.370 | 54.815 | 2.155 | 9.370 | 54.815 |
| 4 | 1.498 | 6.515 | 61.329 | 1.498 | 6.515 | 61.329 |
| 5 | 1.190 | 5.174 | 66.503 | 1.190 | 5.174 | 66.503 |
| 6 | 1.113 | 4.838 | 71.341 | 1.113 | 4.838 | 71.341 |

### 3.3. Name of Extracted Factors

From the factoring results, six variables with the member of factors that seen in Table 4, due to the member of factors the name factors can be named as seen in Table 5. Factor 1 belongs to Main Features, ultimate comfortability, and standard compliance. It is indicated that variables such as safety, comfortability, durability, conformity with standard, and main features such as body support and adjustable footstep are important exist in the wheelchair for children with CP, on the other hand this finding in line with research by Pradita et al. (Pradita, Priadythama and Susmartini, 2018). Then factor 2 belongs to strong materials with variables strong stopper, strong frame, and stability when in use. Then factor 3 belongs to ergonomics, due to the wheelchair need to fit body posture, comfortable seat cushion backrest, footrest, and armrest that must

**Table 4.** Rotated component matrix.

| No item | Variables | Component | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| no_6 | A body support is needed on the right and left side of the wheelchair | .582 | | | | | |
| no_7 | A wheelchair must have adjustable footstep | .824 | | | | | |
| no_8 | A wheelchair must have comfortable and adjustable footrests | .708 | | | | | |
| no_9 | You are concerned about the high level of safety in wheelchairs | .692 | | | | | |
| no_10 | You are prioritizing a wheelchair with a high level of comfort | .871 | | | | | |
| no_16 | You are very concerned about the durability of the wheelchair, such as non-flammable and non-corrosive | .412 | | | | | |
| no_17 | You are very concerned about the durability of the wheelchair, such as not being damaged in a fall and components that are not easily damaged | .615 | | | | | |
| no_20 | A wheelchair must be standard and certified by SNI | .491 | | | | | |
| no_23 | A wheelchair should be easily accessible | .655 | | | | | |
| no_13 | A wheelchair must be equipped with a strong stopper. | | .922 | | | | |
| no_14 | A wheelchair must be equipped with a frame that is strong and able to withstand the load | | .923 | | | | |
| no_15 | A wheelchair must be stable when in use | | .904 | | | | |
| no_1 | The use of a wheelchair is necessary to support your daily activities | | | .729 | | | |
| no_2 | A wheelchair has to fit your posture | | | .828 | | | |
| no_3 | A wheelchair must have comfortable seat cushions, backrests, footrests and armrests | | | .674 | | | |
| no_4 | A wheelchair must have a backrest that can be adjusted according to your needs | | | .577 | | | |
| no_5 | A wheelchair must have an adjustable headrest to suit your needs | | | | .529 | | |
| no_11 | You are very concerned about the convenience of using a wheelchair, such as being easy to operate, easy to move around, and able to overcome obstacles. | | | | .502 | | |
| no_12 | A wheelchair must be equipped with a seat belt | | | | .854 | | |
| no_22 | A wheelchair must have additional functions such as a folding table or luggage bag | | | | .650 | | |
| no_18 | A wheelchair can be folded and compact when not in use | | | | | .552 | |
| no_19 | A wheelchair should be lightweight | | | | | .862 | |
| no_21 | You are very concerned about the design of the wheelchair, as it should be attractive, colourful, and patterned | | | | | | .761 |

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 7 iterations.

**Table 5.** Name of extracted factors.

| Factors | Factor's Name |
|---|---|
| 1 | Main features, ultimate comfortability, and standard compliance |
| 2 | Robust durability |
| 3 | Thoughtful Ergonomics |
| 4 | Unique special features |
| 5 | User-friendly design |
| 6 | Aesthetic appeal |

comply with the anthropometry of the user, on the other hand anthropometric data for common user is different than disability person (Isharyadi and Ningtyas, 2013). Factor 4 belongs to special features that need to add in the wheelchair for CP, that must have adjustable headrest, seatbelt, folding table, and easy to operate. Factor 5 belongs to Ease of Use especially for caregiver that wheelchair can folded and lightweight. factor 6 belongs to design of the wheelchair. Similarly, those findings are agreed upon by Mohd et al., that designing wheelchairs for individuals with disabilities must include factors such as operability, transportability, foldability, comfort, and aesthetics (Ho *et al.*, 2020).

## 4. CONCLUSION

There were some researchers to designing a wheelchair for children with CP but need factors to develop a wheelchair for children with CP has still lacked. The findings revealed six fundamental factors to consider when designing wheelchairs for children with CP: Main features, Ultimate comfort, standard compliance, robust durability, thoughtful ergonomics, unique special features, user-friendly design, and aesthetic appeal. In summary, while the main features are crucial in the design of wheelchairs for children with CP, it is equally important that these wheelchairs comply with applicable standards and incorporate special features tailored specifically for these young users.

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## REFERENCES

Carlon, S.L. *et al.* (2013) ‘Differences In Habitual Physical Activity Levels Of Young People With Cerebral Palsy And Their Typically Developing Peers: A Systematic Review’, *Disability and Rehabilitation*, 35(8), pp. 647–655. Available at: https://doi.org/10.3109/09638288.2012.715721.

Ekiz, T. *et al.* (2017) ‘Wheelchair Appropriateness In Children With Cerebral Palsy: A Single Center Experience’, *Journal of Back and Musculoskeletal Rehabilitation*, 30(4), pp. 825–828. Available at: https://doi.org/10.3233/BMR-150522.

Goodlich, B.I. *et al.* (2020) ‘Machine Learning To Quantify Habitual Physical Activity In Children With Cerebral Palsy’, *Developmental Medicine and Child Neurology*, 62(9), pp. 1054–1060. Available at: https://doi.org/10.1111/dmcn.14560.

Ho, M. *et al.* (2020) ‘The Process Of Designing Special Wheel Chair For People With Physical Disabilities’, *Malaysian Journal of Public Health Medicine*, 20(Special1), pp. 192–200. Available at: https://doi.org/10.37268/mjphm/vol.20/no.Special1/art.706.

Isharyadi, F. and Ningtyas, D.R. (2013) ‘Kesesuaian SNI 12-0179-1987 Bagi Penderita Disabilitas Di Indonesia’, *Jurnal Standardisasi*, 15(3), pp. 230–239. Available at: https://doi.org/10.31153/js.v15i3.126.

Kharisma, A. and Indrojarwo, B.T. (2017) ‘Desain Kursi Roda dengan Sistem Kemudi Tuas sebagai Sarana Mobilitas bagi Anak Penderita Cerebral Palsy Usia 6 hingga 10th’, *Jurnal Sains dan Seni ITS*, 5(2), pp. 271–275. Available at: https://doi.org/10.12962/j23373520.v5i2.21007.

Levitt, S. and Addison, A. (2018) *Treatment of Cerebral Palsy and Motor Delay*. John Wiley & Sons. [Print].

Llontop, D.A.R. *et al.* (2020) ‘Mechatronics Design and Simulation of Anthropomorphic Robotic Arm mounted on Wheelchair for Supporting Patients with Spastic Cerebral Palsy’, in *2020 IEEE International Conference on Engineering Veracruz (ICEV). 2020 IEEE International Conference on Engineering Veracruz (ICEV)*, Boca del Rio, Mexico: IEEE, pp. 1–5. Available at: https://doi.org/10.1109/ICEV50249.2020.9289665.

Maher, C.A. *et al*. (2007) 'Physical And Sedentary Activity In Adolescents With Cerebral Palsy', *Developmental Medicine and Child Neurology*, 49(6), pp. 450–457. Available at: https://doi.org/10.1111/j.1469-8749.2007.00450.x.

Malik, F., Kamran, S. and Sarfraz, S. (2022) 'Exploratory Factor Analysis of Internal Resource Based View for New Product Development Process in Pakistan'S Manufacturing Sector', *Pakistan Journal of Social Research*, 4(2), pp. 222–233. Available at: https://doi.org/10.52567/pjsr.v4i2.470.

Mardiana, D.P., Pujianto, M.R. and Sulistyo, S. (2020) 'Perancangan Kursi Roda Ergonomis Untuk Orang Manula', *Journal of Industrial Engineering and Technology*, 1(1), pp. 11–17. Available at: https://doi.org/10.24176/jointtech.v1i1.5618.

Mboi, N. (2014) 'Peraturan Menteri Kesehatan Nomor 25 Tahun 2014 tentang Upaya Kesehatan Anak'. Permenkes. Available at: https://peraturan.bpk.go.id/Details/117562/permenkes-no-25-tahun-2014 (Accessed: 19 December 2024).

McNeish, D. (2017) 'Exploratory Factor Analysis With Small Samples and Missing Data', *Journal of Personality Assessment*, 99(6), pp. 637–652. Available at: https://doi.org/10.1080/00223891.2016.1252382

Ordóñez, B.Q. *et al*. (2021) 'Application of Exploratory Factor Analysis in the Construction of a Self-Perception Model of Informational Competences in Higher Education', *Mathematics*, 9(18), p. 2332. Available at: https://doi.org/10.3390/math9182332.

Pradita, A.A., Priadythama, I. and Susmartini, S. (2018) 'Perancangan Ulang Kursi Roda Manual Menggunakan Kriteria Standar ISO 7176-5', *Performa: Media Ilmiah Teknik Industri*, 17(1), pp. 54–60. Available at: https://doi.org/10.20961/performa.17.1.19068.

Pratiwi, R.A. *et al*. (2019) 'Usulan Kerangka Standar Kursi Roda Manual Sebagai Acuan Penyusunan Standar Nasional Indonesia (SNI)', *Jurnal Standardisasi*, 20(3), pp. 207–217. Available at: https://doi.org/10.31153/js.v20i3.724.

Rodby-Bousquet, E. *et al*. (2016) 'Physical Risk Factors Influencing Wheeled Mobility In Children With Cerebral Palsy: A Cross-Sectional Study', *BMC pediatrics*, 16(1), p. 165. Available at: https://doi.org/10.1186/s12887-016-0707-6.

Tanjung, A.S. and Sinaga, N. (2022) 'Karakteristik Pasien Palsi Serebral Di Rumah Sakit Haji Medan tahun 2020-2021', *JURNAL ILMIAH SIMANTEK*, 6(4), pp. 79–88.

Yong, A.G. and Pearce, S. (2013) 'A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis', *Tutorials in Quantitative Methods for Psychology*, 9(2), pp. 79–94. Available at: https://doi.org/10.20982/tqmp.09.2.p079.

Zakiyah, U.M., Setiawan, R. and Rosnawati, R. (2022) 'Exploratory Factor Analysis: Factors that Affects Parents' Decision to Choose Private Elementary Schools in Pandemic Covid19', in. *Annual Conference on Research, Educational Implementation, Social Studies and History (AREISSH 2021)*, Yogyakarta, Indonesia: Atlantis Press, pp. 237–248. Available at: https://doi.org/10.2991/978-2-494069-17-6_26.

Zupan, A. and Jenko, M. (2012) 'Assistive Technology For People With Cerebral Palsy', *Eastern Journal Of Medicine*, 17(4), pp. 194–197.