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Clothing Needs for Wheelchair Users: A Systematic Literature Review

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Abstract

The aim of this study was to identify the clothing needs of wheelchair users using relevant literatures in a global scale and to design a method to classify the clothing needs into a unified system, in order to generate a map of wheelchair users' clothing needs with the information from multiple resources. The paper reviewed the previous studies about clothing needs and preference of wheelchair users. A three-tier screening was designed to extract main findings from the relevant literature. Content analysis and statistical analysis were used to integrate the information and identify implications. Information was categorized to represent the attributes of the clothing needs. The paper provides comprehensive insights about the specific barriers and abstract demands about the clothing needs of wheelchair users regarding their preference for apparel products. Eight essential attributes relating to the clothing needs of wheelchair users were identified: functional needs, fit attribute fabric and fiber, safety issue, aesthetic needs, expressive needs, quality of life, and extrinsic attributes. The attributes were classified into two general domains, reflecting the physical challenges and psychological desires of wheelchair users.

Keywords

Wheelchair User, Disabled People, Clothing Needs, Apparel, Garment

1. Background

Wheelchair users are one of the types among the disabled and patients. The term "wheelchair user" is explained as "a person who is unable to walk through injury, illness, etc., and relies on a wheelchair to move around" according to Collin dictionary [1]. It was also mentioned that the phrase usually refers to a long-term wheelchair user [2]. The disability of wheelchair users is basically

considered as mobility impairment [3] or described as "living with mobility disabilities and impairments" [4]. It means that the person is permanently keeping a seated poster in the wheelchair rather than standing [5] [6], and the posture leads to the direct problems of dependency on technical aid, restriction within the wheelchair, or even indirect function problems such as the atrophy of the leg muscle [5], poor blood circulation [7] and reduction of sensation [8]. These problems can include primary injuries and diseases such as spinal cord injuries, atrophy of leg muscles, chronic urinary infection, skin inflammation, pressure sores [9], and cardiovascular problems [10]. Consequences include muscle fatigue in the upper extremities [11] [12], poor blood circulation in the lower limbs [7], shoulder pain [13] [14], neck pain [15] [16] [17] [18], pain in lower back/the buttocks [19] [20] [21] as well as negative reactions due to personal, interpersonal and environmental barriers [22] [23]. All of these issues can have negative impacts on social participation [24] [25] [26] [27] [28] and "user satisfaction" with their wheelchair devices [29] [30].

Lee & Jin [8] classified the disabilities of wheelchair users into eight levels that resulted from paraplegia and quadriplegia. However, the causes of being a wheelchair user could be even more than the reasons. A person at very old age could also possibly lose the capability of joint movement therefore require the assistance of a wheelchair for mobility. According to the international classification of function (ICF), [31] [32] from WHO, wheelchair users, as a group of disability of mobility, could be classified under the subtitle of impairments in body function of movement. Five scales were suggested to evaluate the level of the disability, from 0 no impairment to 4 completely impairment.

The clothing needs of wheelchair users were discussed mainly on the functional application adjustment to reduce the physical strain for the wearer and to lessen the burden of caregivers. It was mentioned repeatedly about the wheelchair user facing difficulty in finding a suitable garment with a good fit to the deformed body contour, either for the sitting posture or the deformed curve resulted from lack of exercise [3] [33] [34]. Though the studies are accumulative regarding the concern about the wellbeing of wheelchair users, the results of all the studies are dispersed from different angles of view, but not integrated as a systematic whole instruction. There were studies related to apparel design, shopping behavior, medical treatment, and social impact, but the core reason of wheelchair users having clothing needs is fundamentally from their special situation that they are living with wheelchairs. The author of this study tried to generate a conceptual framework incorporating fashion design [35], apparel preferences and needs of wheelchair users [3], and subjective assessment of disabled patients [36], to obtain a systematic classification of the physical and psychological aspects of wheelchair users' clothing-related needs. This paper attempts to analyze the previous studies and critiques regarding wheelchair users' clothing needs and the apparel products available to them. This analysis had two purposes: 1) to understand the current apparel product design and markets for wheel-

chair users and 2) to analyze the clothing needs into a systematic sequence.

2. Objective and Methodology

In this literature review, we try to integrate the overall findings from previous researches regarding the clothing needs of wheelchair users, as well as persons with mobility disabilities and impairments, in order to identify the average understanding about the clothing needs of wheelchair users. The purpose of obtaining the integration of clothing needs is to instruct the development of apparel product design, fashion business expansion for the minor group of disabled customers, and to enhance the wellbeing of wheelchair users by encouraging their participation into the apparel market. To achieve the overall information, this study has planned to find the answer to the following two questions:

1) What are the overall clothing needs of wheelchair users?

2) How the clothing needs weigh in the apparel selection when consider the importance to wheelchair users?

To answer the questions, a systematic methodology has been designed using the relevant literatures.

The literature searching and screening follows a three-tier procedure. The primary search started with a systematic search of the databases of SAGE, Elsevier, Taylor & Francis, Ovid, Google Scholar, Wiley online Library, Nature, Oxford Academics, Scopus, and Springer from 1980 to 2019. The key words used for the primary search followed the sequence:

1) "Wheelchair user/users";

2) "Wheelchair user/users" + "clothing needs";

3) "Wheelchair user/users" + "apparel";

4) "Wheelchair user/users" + "garment".

The overall literature search identified 941 primary sources. For the full-text articles identified, the titles and abstracts were examined closely to ensure that the content was related to both "wheelchair user" and "clothing-related" studies. Eligibility was limited to articles published in journals and dissertation resources in English, yielding a total of 16 studies considered to be directly relevant to the clothing needs of wheelchair users (see **Figure 1**). Ancestral searches were conducted using the reference to identify further articles deemed to be relevant to the review. These studies were included if the topics were related to:

- Apparel design and development for wheelchair users and other disabled consumers;
- Requirements regarding apparel and purchasing method for wheelchair users;
- Marketing and environmental support for disabled customers;
- Preferences and behaviors of disabled customers and wheelchair users;
- Rehabilitation methods involving garments as solutions;
- Patient care and nursing when medical garments were considered as one of the elements;

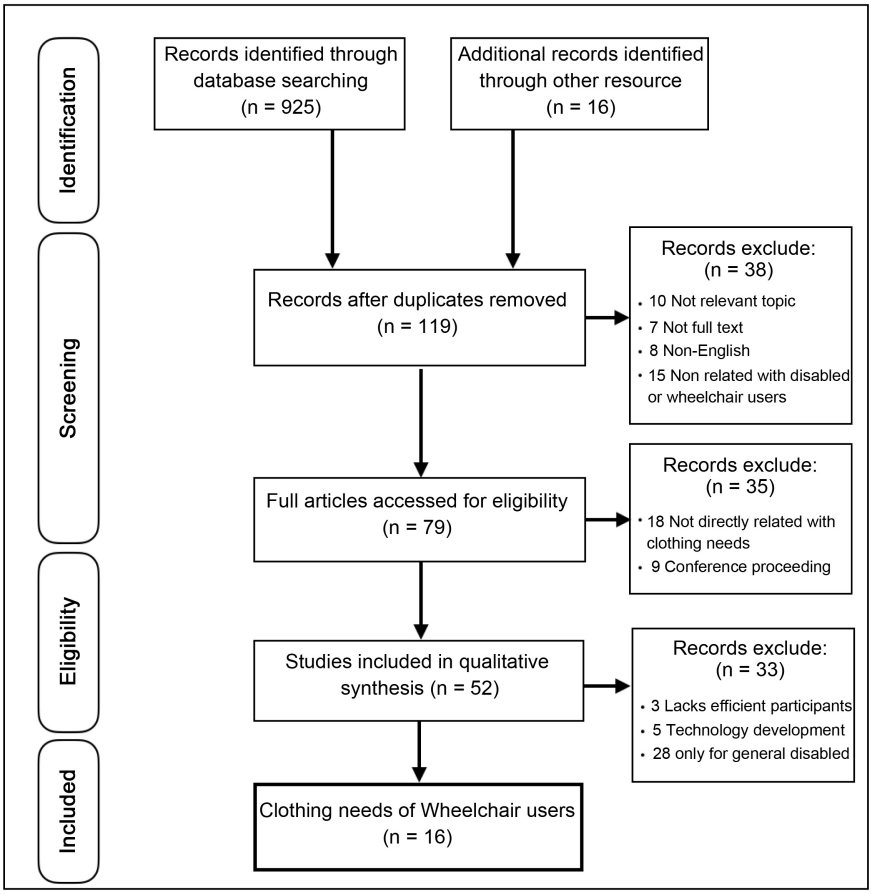

Figure 1. Flow chart of the selection process of the literatures.

In general, the selected studies were screened according to a three-tier method, as shown in **Figure 2**. First, the clothing-related barriers and needs of wheelchair users were identified from the findings regarding individual problems and experiences, thus the original descriptions in the interviews could be extracted. Second, the respondents' interview responses were categorized according to key words that represented the attributes of the clothing needs. These attributes were based on the specific intentions suggested by the individual interviewees. Finally, the key words were classified further using a cluster analysis method to generate four dimensions as the main domains of study.

In order to assess the literature in various research domains, an incremental method of analysis was designed to evaluated the information from the literatures, and a method combining content analysis and statistical analysis using NVivo 12 plus and SPSS was explored from both qualitative and quantitative perspectives. All the literatures about the clothing needs of the people with disabilities were divided for a three-stage analysis (see **Figure 3**):

1) In the first stage, the overall selected works that directly related with the clothing needs of wheelchair users have been examined and extracted from their main findings. The findings provide a comprehensive knowledge about the basic research progress regarding the apparel for wheelchair users. In this stage, the

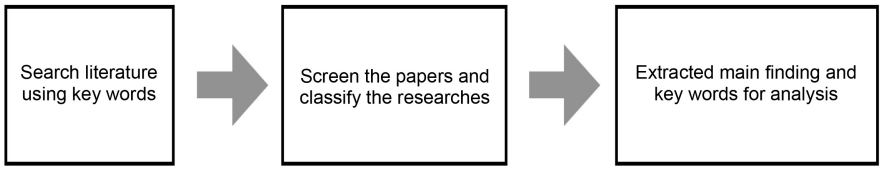

Figure 2. The information process in the literature review.

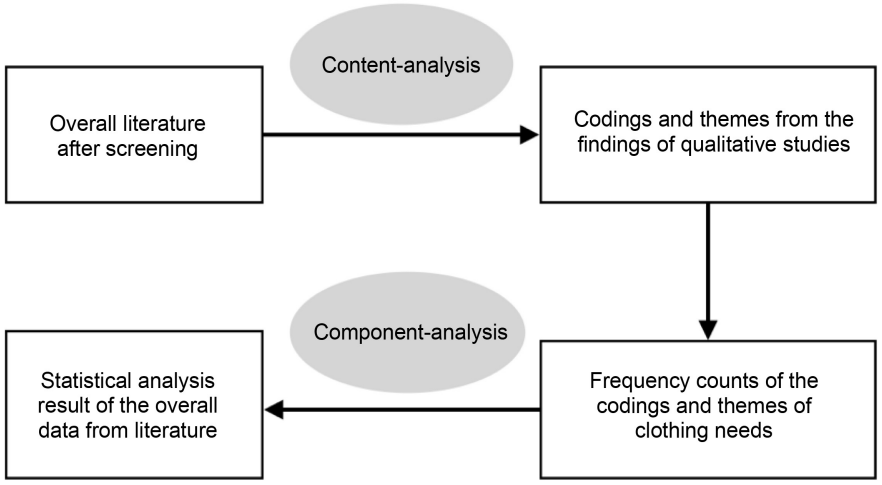

Figure 3. The procedure of data analysis using the literatures.

results of all the literatures could be evaluated and compared, so that a classification of clothing needs could be integrated into a unified system while the errors and bias in each study could be corrected.

2) In the second stage, the method of content analysis was applied to the narrative description of the clothing needs and barriers of current disabled persons in the selected publication, in which key words were coded and classified into themes that could represent the main attributes of the clothing needs of wheelchair users. The classification is referred to the FEA (functional, expressive, aesthetic) model of Lamb & Kallal [35] and further modification was determined according to the findings in the publications. The frequency of the key words could be counted form the text in order to reveal the importance of clothing needs to wheelchair users. Comparison among the publication could also be revealed from the attributes.

3) In the third stage, the attributes that obtained from the stage 2 were further explored using SPSS to conduct statistical analysis. The method follows the evaluation method of AHP process to determine the weight of factors and Component analysis to generate the groups of clothing needs, so that the exploration is able to gather all the attributes from each publication into a unified system of assessment. The frequency of each key words and attributes were converted into a ranking of importance of clothing needs from wheelchair users' perspective, and then the statistical analysis was applied to the ranking of attributes. The output of the quantitative analysis illustrated comprehensive understanding of clothing needs from all the literature.

3. Result

3.1. General Overview of the Literatures

The overall information gathered of the selected literatures is listed in Table 1. Among the sixteen studies, ten studies are directly related with the aim of investigating the clothing needs of wheelchair users, two introduced the clothing preference through the adaptive apparel for wheelchair users. Three studies explored the clothing needs and preference for the purpose of garment design and development for the targeted wearers, and one study tried to develop a design model framework using theoretical information for the disabled people. With regard to the study methodology, all of the researches chose qualitative approach, and four of them conducted group interview, six researches sent out survey and questionnaires, and three studies adopted case studies. Main findings are also extracted from the context and the location where the researchers conducted the studies is also listed in order to further illustrate the environment of the participated wheelchair users.

The findings of the studies are also based on various situations of wheelchair users. [37] Focused on the apparel needs of sports athletes, especially for the exercises. Kratz *et al.* [38] has also compared the adaptive apparel and common apparel for disabled wearers of sailing, rugby, and walking activities. Abraham-Murali *et al.* [39] investigated the criteria of and attributes of clothing evaluation of female wearers, and Kabel [40] collected data of only male participants. The findings about clothing needs are similar on a large scale.

3.2. Key Words Extraction and Classification

The key words extraction was conducted following the procedure of content analysis. The coding process was conducted with NVivo 12 and the coding was extracted based on the sentences of the publications about the clothing needs and experiences of wheelchair users. A word frequency of all the publications could be obtained to reflect the general concerns from wheelchair users (see Figure 4). Design, dressing (together with undressing) and function are the mostly mentioned words, followed by other expressions such as appearance, comfort, participation (especially referring to social participation), and other factors such as fitting, performance, quality, style, etc. Pants/trousers and the waist design are the most concerned parts regarding the design suggestions, followed by fastener selection of zippers and Velcro.

Coding was extracted line by line from the literatures and then generated into themes. Similar codes were combined into one theme, and the themes were designed to ensure that no obscureness is between the concepts. Eight themes were finally determined to represent the overall clothing needs of wheelchair users. The eight themes contain Functional needs, Aesthetic needs, Expressive needs, Fabric and fiber, Quality of life, Safety, Extrinsic attributes. In addition to the functional needs, Fit has been found to be frequently discussed and the topic

Table 1. Details of eligible studies. The evaluation of all the studies include the study methodology feature, participation characteristics, and the area of which the studies were applied. Findings were extracted for further comparison.

Item	Number of participants	Research approaches	Country or Location	Main findings
Abraham-Murali *et al.* 2001 [39]	19	Group interview	New York State, US	1) A list of 49 attributes of clothing was extracted from the interview, and could be classified into four criteria: physical appearance (58.10%), physical performance (29.82%), expressiveness (10.29%), and extrinsic attributes (1.77%). 2) Casual or lounge wear was the choice of garments for all respondents. Most participants preferred regular undergarments from stores. Rarely did the respondents purchase formal or business wear, except for special occasions.
Kabel, Dimka & McBee-Black 2017 [41]	113	Online survey	US	1) Over half of the respondents reported having declined participation in activities or events because of the lack of appropriate or acceptable clothing. 2) Nearly half of individuals with employment barriers reported concerns with finding appropriate interview clothing or suitable occupation-specific clothing. Suitable clothing for different seasonal and weather conditions was also mentioned in relation to health and safety concerns. 3) Clothing barriers prevent respondents with mobility challenges from health-promotion activities such as exercise. Swimwear and athletic clothes were mostly reported to be inaccessible.
Braganca *et al.* 2018 [37]	61	Group interview and semi-structured questionnaire	UK	1) Tops and bottoms presented issues mainly related to fitting and ability to regulate the core body temperature. 2) Gloves impacted negatively on players' ability to participate with satisfactory level of protection and comfort. 3) Materials of the apparel were preferred to be water-absorbent, high-performance, tough, soft and also breathable. 4) Design recommendations were listed to provide information on the needs and requirements of athletes with disabilities.
Suri 2016 [3]	160	Questionnaire	Kent, US	1) Positive relationships were found between the FEA model (Lamb & Kallal, 1992) and three domains of the quality of life model, showing that well-designed and fitted garments can help boost self-confidence, therefore promoting inclusion in society. 2) In the Quality of Life model, psychological aspects had a significant relationship with expressive and aesthetic elements of clothing ($p < 0.01$). Level of independence had a significant relationship with functional and expressive elements of clothing ($p < 0.01$). Social aspects had a significant relationship with function and aesthetic elements of clothing ($p < 0.01$). 3) Some of the unsatisfactory ready-to-wear clothing attributes such as ease of putting on and taking off, fit, movement, protection, usability, and comfort, were given attention while developing adaptive clothing for wheelchair users. 4) Respondents were most dissatisfied with trousers, followed by jeans, cargo pants, shirts, and outerwear jackets. 5) Advanced textile research is needed to incorporate specialized fabrics like antimicrobial and moisture wicking fabric to avoid potential bacteria growth and malodor.

Continued

Kabel 2019 [40]	2	Case study	US	1) Body temperature was found to be a challenge for people living in wheelchairs. Warmth and comfort were the participants' main clothing needs. 2) Staying safe and coping with risk was another challenge for wheelchair users because they had problems with clothing being incompatible for wheelchair users or that failed to meet their needs. Particular problems were loose clothing getting caught in wheelchair wheels, and shirt sleeves getting caught in the Samuel chair and power chair. 3) The lack of appropriate attire for formal occasions was mentioned by participants, as wheelchair users were also conscious of appearance. Clothing trends did not translate to adaptive wear. 4) Apparel choices of wheelchair users required planning to keep warm, prevent injury, and create the proper impression/style to maintain access to the social realm.
Wang *et al.* 2014 [42]	58	Questionnaire	Shanghai, China	1) An evaluation system using dressing and undressing, bathing, and using toilet was developed in relation to the assessment of clothing for wheelchair users. 2) Taking off and putting on items fitting the crotch were identified as the most difficult movements for wheelchair users. 3) Three requirements of wheelchair clothing needs are: pants with easy dressing and undressing functions, joint locations that make limb movements easier, and soft and water absorbent fabrics to be used for keeping warmth. 4) Newly-designed clothing was looser, more air permeable and more comfortable in tactile sensory, which could meet the wheelchair users' requirements.
O'Bannon *et al.* 1988 [43]	90	Questionnaire factor analysis	Columbia, US	1) Social, physical, psychological, performance, economic, and overall risk were measured to identify the perceived risk and shopping considerations of the disabled consumers. 2) Three factors, mass media source, retail sources, and personal sources factors were classified as the main information source to influence the apparel acquisition of the disabled consumers. 3) Price, caring for clothing, coordination of garments, fiber content, and budgeting the clothing allowance are the most important topics to the respondents. Performance, flexibility and versatility of garments are major concerns areas. 4) Perceived physical risk ranked highest and perceived social risk lowest for wheelchair-bound consumers.
Rudolf & Stjepanovic 2017 [7]	58	Questionnaire	Slovenia	1) The most faced problems including incontinence, infection and inflammation of urinary tract, frequent colds, pressure sores, skin irritations and inflammations. 2) Regarding the product of sitting bag for wheelchair users, they want it to be particularly warm, water and wind impermeable and of aesthetic appearance. 3) The sitting bag (textile product for wheelchair users) is expected to be used for social events, long walks, and sport events. 4) It reveals that there is a great need regarding the offer of protective garments for immobile population using a wheelchair on the domestic market, and there is also a high need for the sitting bag that would allow protection against the cold, wind, rain and snow and for the cape with protection against the wind, rain and cold.

Continued

Kaswan & Sudha 2009 [44]	40	descriptive cum exploratory study	Udaipur city, India	1) The majority of respondents (over 80%) were found to be less satisfied or not satisfied with the fitting of garments, and all the respondents wanted loose or medium fitting garments. 2) The majority of respondents were satisfied with garment materials. 3) The majority of respondents were not satisfied or less satisfied with the functional design, especially fasteners. 4) Major problems were in the functional aspects of ready-made garments, loose or medium fitting, openings, neckline designs, and sizes of pockets, etc.
Braganca *et al.* 2017 [45]	61	Group interview and questionnaire	UK	1) Most athletes find problems with the sports-wear and areas that need significant improvements, especially considering fit experiences that may have wider implications. 2) The most common cause of dissatisfaction was the fit of the clothes, followed by the ability to maintain a good temperature and the comfort felt. 3) Items that related with the dissatisfaction include the availability of clothes for the sports, the ease of putting on and taking off, the materials that constitute the clothes, and the impact the clothes have on performance. 4) Among all the items of clothes, the respondents were most unsatisfied with the gloves for sports and it was followed by trousers and sleeveless tops and vests. 5) Comfort is the most important aspect of all for every part of the garment. The least important aspect is safety for athletes. Functionality is as important to the athletes as comfort when making the decision of purchase. 6) The questionnaire also confirmed that the sports-wear stores do not offer a wide variety of garments specific for wheelchair users. 7) The most commonly encountered problems for the athletes are that the ready-to-wear sports-wear does not fit their body shape.
Thompson 2015 [46]	8	Group interview	Toronto, CAN	1) The lack of mainstream clothing available and the geriatric style of clothing often associated with physical disability is largely a result of the embedded notion that disability is a problem to be solved by the individual. 2) As appearance plays a role in interactions, the stereotypes surrounding physical disability are perpetuated if the appearance cannot be changed due to the absence of the type of clothing one might desire to wear.
Kratz *et al.* 1997 [38]	14	Quasi-experimental post-test design	Sweden	1) Wheelchair users felt more comfortable when wearing adapted clothes than their ordinary clothes. These clothes fitted better, were light in weight and easy to wear. 2) How wheelchair users looked after themselves could affect the choice of leisure activity. 3) Adaptive clothes contributed to the wheelchair user's involvement in activities, if they felt more able to concentrate and live up to the expectations of others during challenging activities. 4) Adapted clothes could largely change wheelchair users' moods in a positive direction.

Continued

Lee & Jin 2019 [8]	Not Applicable	theoretical framework	Oregon, US	1) A design framework is developed to assess the sportswear attributes in terms of comfort and enhanced performance for wheelchair users. 2) Wheelchair users' characteristics and the degree of physical disability are associated with their clothing attributes. 3) It is also suggested that age aspect needs to be considered for the personal characteristic dimension. 4) The activity and the fit attributes in the physical dimension are addressed to guide the development of sportswear. 5) The proposed design model offers a sub dimension to improve the fit attribute for the sportswear for wheelchair users depending on the activity. In addition, it can be suggested particularly to identify the unbalanced measurement of bodice for wheelchair users and the difference of the wearing ease for the bodice and sleeve when developing the pattern in the physical dimension.
Eggleston *et al.* 1994 [47]	Not Applicable	Case study	US	1) 17 items of clothing were developed including suits, dresses, blouses, evening skirts, slacks, sports coats, and robes, and caps for wheelchair users. 2) Jacket should not exceed hip bone, and slacks should have high crotch with enough back rise and adequate knee length. 3) Front-openings on garments and separate pockets are suggested. 4) Extra loops of gloves are needed for fastening on wrist, and shoulder bags are recommended.
Howe 2010 [48]	100	Online questionnaire cohesive needs analysis	Australia and US	1) The higher the injury level, the greater the loss of mobility and consequent reliance on carers for basic needs. Higher injury levels also led to greater changes in body shape. 2) People were keen to conceal their stomachs, usually by purchasing larger sizes, but this resulted in clothes not fitting well and posed greater risk of pressure sores. 3) As the difficulty in buying clothes increased, people were more likely to feel unattractive, sloppy and dull in their clothes. 4) Design of existing clothes for wheelchair users is either focused on solutions for one specific client group without generalizing designs and analyses to others, or attempting to design for a wide population but failing to address issues specific to disability subgroups. 5) Widely available clothing solutions for wheelchair users focused predominantly on functional and medical issues and placed less emphasis on emotional, expressive or aesthetic requirements of the clothing. 6) Many solutions do not consider the relationship between body and wheelchair, such as knees, ankles, upper body sizes.

Continued

Sharawat & Hooda 2018 [49]	Not Applicable	Case study	India	1) The main problem for the physically challenged and elderly people was dressing-undressing. 2) They also wanted functionality in their garments, which made their lives easier and reduced effort. 3) They wanted comfortable clothes with functionality. 4) One major problem was also that most people did not know about functional garments and these garments were not available in local areas. 5) Only big brands sold these clothes (functional garments) at high prices. 6) People were ready to use functional garments but were not able to spend extra money on functional clothing. 7) Few people were ready to spend extra money for functional clothes. 8) Some functional garments were designed and finally constructed for physical disabled and elderly wearers. 9) Acceptance tests proved the success and encourage the efforts made to design these special garments.

Figure 4. Word frequency map of the clothing needs from all the literatures.

covers a large scale of apparel development, such as measurement, pattern design, and sizing system. Therefore, fit has been listed as an independent theme in this study. Table 2 has demonstrated the amount of codes that appeared in the literatures in all the themes.

Table 2. Total amount of codes in the themes from the literature.

Cases	Aesthetic needs	Expressive needs	Extrinsic Attributes	Fabric and fiber	Fit	Functional needs	Quality of life	Safety	Total
Abraham-Murali & Kane 2001	3	2	2	2	9	7	1	0	26
Braganca *et al.* 2018	1	0	3	1	6	11	0	2	24
Braganca *et al.* 2018	0	0	7	8	16	15	0	2	48
Eggleston *et al.* 1994	1	0	3	1	4	6	0	0	15
Howe 2010	3	2	0	0	4	7	2	4	22
Kabel 2019	4	3	3	2	4	14	2	2	34
Kabel, Dimka & McBee-Black 2017	2	4	1	1	3	12	6	4	33
Kratz *et al.* 1997	0	0	0	0	1	2	1	0	4
Lee & Jin 2019	1	0	0	2	6	3	0	1	13
O'Bannon *et al.* 1988	0	2	3	1	0	4	0	0	10
Kaswan & Sudha 2009	0	0	0	0	6	2	0	0	8
Rudolf & Stjepanovic 2017	1	1	1	1	0	2	0	2	8
Sharawat & Hooda 2018	1	0	1	1	3	6	0	0	12
Suri 2016	6	0	4	8	10	17	1	3	49
Thompson 2015	6	2	3	2	11	10	3	1	38
Wang *et al.* 2014	0	0	0	2	1	2	0	1	6
Total	29	16	31	32	84	120	16	22	350

Among the eight themes, functional need is the most collected concerns among all the studies. Even though the fitting attribute is also an important factor that influencing the functionality of apparel, the basic performance of the garment still counted as the most discussions. Regarding the details of the functional needs, the mostly reported clothing needs are dressing and undressing issues and regulating the body temperature, especially keeping warm during winter climate. Comfort is another popular topic, followed with the functional adjustment on the apparel to be compatible with the wheelchair. In addition, many studies found that wheelchair users have difficulty in managing the fastening of their clothes. This is also discussed with the topics about opening design of the garment and proper fastener selection. Sportswear is a type of garment that wheelchair user or athletes look for. Those interviews that related to sports and exercises focused more on the performance of the garment and technology on adaptive clothes. They also paid attention on the accessories such as gloves and expected a good coordination among garment items.

Fitting is defined as a part of the functional application of the apparel. But in this study, it is listed as an individual theme because the content about the overall fitting of garments contains a broad range of topics. The overall codes about fitting issues took the second large proportion of the data, with the apparel length

of trousers, skirts, crotch, waist, and sleeves ranking at the top of sub-divided groups. The loose and tightness of the garment also took a considerable percentage, in which wheelchair users usually claimed about the either too large apparel that could cause inconvenience or too tight designs that makes them uncomfortable. Except for the measurements there were also desires from wheelchair users about having more allowance in the garment design for body movement and various postures, tougher discussed with the issues about sizing system that is not set up for the seated position and body contour of wheelchair users, causing the apparel bunched up at the back and shoulders leading to the exposure of the lower back and the waist.

Safety is also listed as an individual item other than functional application because the findings from the literature stress it as a health-related problem, not merely the convenience of daily activities. The theme contains topics about redundant material of garment frequently get caught into the wheels, and the improper application materials that causing the pressure sore and skin inflammation. Other protections were also mentioned about taking care of the stomach, bowel and bladder, as well as special cases such as the obesity and diabetic health risks. Safety of the care-giver was mentioned in one of the studies, with a participant pointing out that the care-giver is possibly injured when transferring the patients to the wheelchairs or in dressing procedure.

Fabric and fiber issues are mainly about the selection and preference of the materials of the garment. The result of the codings is similar to most of previous studies, contains the needs about breathability of the fabric, durability, softness feelings and the expectation from the wearers wishing the fabrics to be robust, and tough enough to endure the fraction of the wheelchairs. The studies reported additional needs of the anti-bacterial design for long-time sitting posture in order to avoid the bacterial growth that causing the malodors. High performance material is desires for the wearers who have an active daily life with sports and outdoor exercises.

Even though the functional needs and material performance occupied the largest proportion of the findings in the studies, aesthetic needs, issues regarding the quality of life and extrinsic attributes are also at almost the same level of amounts. Extrinsic attribute refers to the topics that not directly related with the garment but closely influenced the apparel acquisition and assorted services. Details include the customization choices of the apparel items, price, possibility of in-store purchases, and online purchase. Aesthetic needs were discussed about the difficulty of wheelchair users to find a fashionable and stylish piece of item, or the demand of better appearance and attractive by decorating themselves with various clothes. Color has been one of the elements because it was claimed that most choices for them are adaptive clothes with monotonous colors, even limited types of designs.

The quality of life took up a fairly considerable number of findings in the literature. It was related with the mental health and psychological well-being of wheelchair users. One of the benefits from the garment is to gain good feelings

and enhance the confidence of self-dignity of the wearers, which is also pursued by wheelchair users according to the previous studies. Expressive needs are related with the demand of expression personalities about the wearers, not only about the aesthetic and quality of life, but are more about to identify the "self" at the level of communication using apparel as a media. In this area, findings covered the codes about the desire of social participation, but more situations were about the risk of social marginalization caused by the difference of their apparel. Similarly, the wearers would like to change the public stereotypes about disability by dressing the regular types of garment like the able-bodied persons in order to gain equal treatment as anyone else. Figure 5 illustrated the subdivision of the coding of all the themes.

In the literature, not only the clothing needs and expectations were discussed and collected. The suggestions regarding the design modification was also reported. For example, regarding one of the most concerned problems in current apparel, the closure design and fastener selection, wheelchair users offered their personal opinions about their desired method: using zippers and Velcro, or snap fastener to reduce the time consumed in manipulating the buttons when dressing on. However, there were also claims about preferring not using Velcro on the apparel because the accessories would cause extra pressure and friction on the skin leading to pressure sore or scratches. Front and back opening is more discussed over the normal design of garment, because it was said to be user-friendly for the caregivers when dressing up wheelchair users. Another factor to cause the skin problem is the placement of seams, especially at the back of trousers, because it was claimed to add pressure upon the thing. There were also suggestions regarding the waist design, which was always reported to be too low when sitting, causing the exposure of the lower back. Elastic waist design and

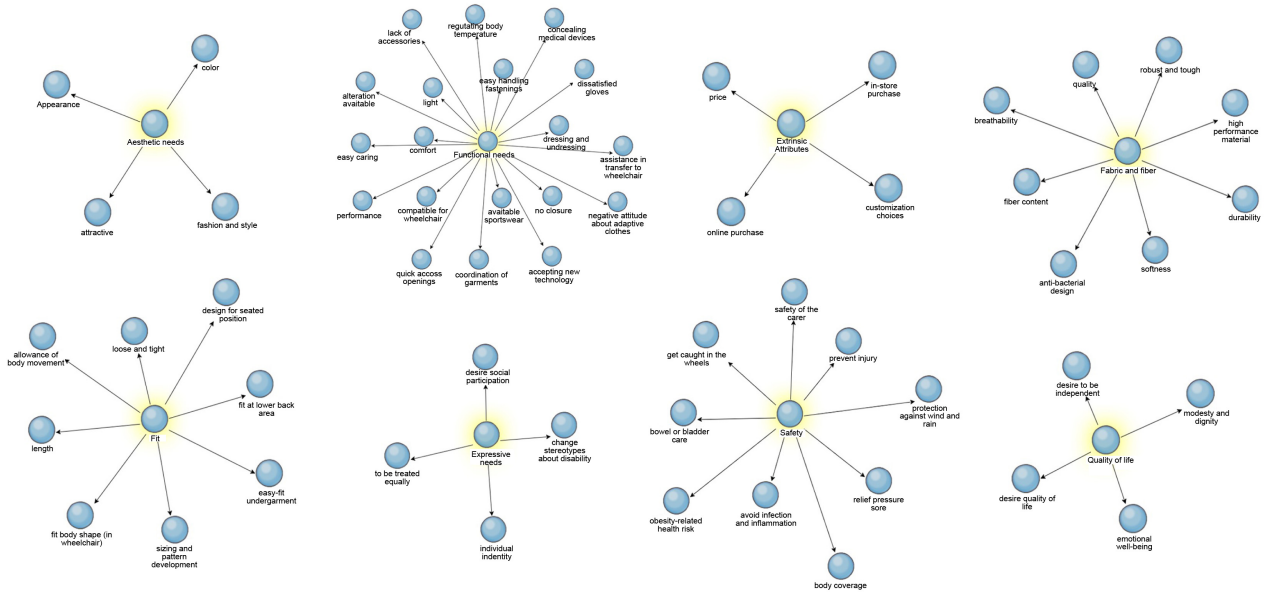

Figure 5. The branches of subdivision coding in the themes.

high rise waist design of the trousers were mostly welcomed among wheelchair users. In addition, pocket design and the collar design was also mentioned in the literature, one is related with the comfortableness and the other is about the convenience of daily activities.

In general, wheelchair users desire their apparel to be regular. According to the literature, they would like their clothing to have the regular features as others, including regular undergarments. There is also a demand of versatility in items among clothing designs, because there are limited choices for wheelchair users to select during purchase. For some specific problems, there could be holistic design solutions on the apparel and most wheelchair users sharing same problems could have more choices in store rather than looking for helpers to modify their garment. Even though the wearable technology is positively accepted among the athletes, there was still demand about applying fewer gadgets for the wears on their apparel.

3.3. Weight Analysis and Component Analysis

The result of the coding distribution was further assessed using the method of Analytical Hierarchy Process to determine the weight of impact of each theme. The analysis was conducted using the SPSSAU 18.0 online analysis software. According to the study design, the amount of the frequency represents the times of appearance during the data collection of the qualitative of previous studies. Also it represents the importance of the issue in the consideration of wheelchair users for apparel preference. Under each theme, the subdivision of coding also revealed the detailed clothing needs of wheelchair users. Therefore, the analytic hierarchy process has been conducted using the frequency of the coding in the subdivision of eight separate themes. Table 3 has demonstrated the result.

In the functional needs theme, eighteen items were obtained from the content analysis and the maximum eigenvalue is 18. Among all the weight value of the items, four items: dressing and undressing, regulating body temperature, compatible for wheelchair users, and comfort are the most weighted items. Lack of accessories and having no closure on the garment were rated at the lowest weight among all the items. Besides, items of easy handling fastenings and performance are also at a relatively higher weight among all the items.

In the fit theme, eight items were obtained from the content analysis and the maximum eigenvalue is 8. Among all the weight value of the items, three items: fit body shape (in wheelchair), loose and tight feature, and length are the most weighted items. Easy fit undergarment is the lowest weight among all the items.

In the fabric and fiber theme, there were also eight items analyzed and the maximum eigenvalue is 8. Three items: breathability, durability and softness are the most weighted items. On the contrary, high performance materials and robust/toughness of the fabric were rated at the lowest weight among all the items. Anti-bacterial design using functional fabric is also highly weighted, following the top three items.

Table 3. The weight analysis of subdivision of clothing needs in eight themes.

3-(1) Functional needs weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
accepting new technology	0.281	1.563%		
alteration available	0.422	2.344%		
assistance in transfer to wheelchair	0.703	3.906%		
available sportswear	0.844	4.688%		
comfort	2.531	14.063%		
compatible for wheelchair	2.109	11.719%		
concealing medical devices	0.563	3.125%		
coordination of garments	0.281	1.563%		
dressing and undressing	2.953	16.406%		
easy caring	0.422	2.344%	18	0
easy handling fastenings	1.406	7.813%		
lack of accessories	0.141	0.781%		
light	0.563	3.125%		
negative attitude about adaptive clothes	0.281	1.563%		
no closure	0.141	0.781%		
performance	1.125	6.250%		
quick access openings	0.422	2.344%		
regulating body temperature	2.813	15.625%		

3-(2) Fit attribute weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
allowance of body movement	0.898	11.224%		
design for seated position	0.816	10.204%		
easy-fit undergarment	0.082	1.020%		
fit at lower back area	0.98	12.245%		
fit body shape (in wheelchair)	1.633	20.408%	8	0
length	1.143	14.286%		
loose and tight	1.388	17.347%		
sizing and pattern development	1.061	13.265%		

3-(3) Fabric and fiber weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
anti-bacterial design	1.053	13.158%		
breathability	2.316	28.947%		
durability	1.474	18.421%		
fiber content	0.632	7.895%		
high performance material	0.211	2.632%	8	0
quality	0.842	10.526%		
robust and tough	0.211	2.632%		
softness	1.263	15.789%		

3-(4) Safety weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
avoid infection and inflammation	0.818	9.091%	9	0
body coverage	0.409	4.545%		
bowel or bladder care	0.409	4.545%		
get caught in the wheels	3.273	36.364%		
obesity-related health risk	0.409	4.545%		
prevent injury	0.409	4.545%		
protection against wind and rain	0.818	9.091%		
pressure sore	2.045	22.727%		
safety of the carer	0.409	4.545%		

3-(5) Aesthetic needs weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
Appearance	1.333	33.333%	4	0
attractive	0.8	20.000%		
color	0.4	10.000%		
fashion and style	1.467	36.667%		

3-(6) Expression needs weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
change stereotypes about disability	0.286	7.143%	4	0
desire social participation	2.857	71.429%		
individual identity	0.571	14.286%		
to be treated equally	0.286	7.143%		

3-(7) Quality of life attribute weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
desire quality of life	0.235	5.882%	4	0
desire to be independent	0.706	17.647%		
emotional well-being	2.353	58.824%		
modesty and dignity	0.706	17.647%		

3-(8) Extrinsic attribute weight analysis

Item	Eigenvector	Weight value	Maximum Eigenvalue	CI Ratio
customization choices	1.935	48.387%	4	0
in-store purchase	0.774	19.355%		
online purchase	0.129	3.226%		
price	1.161	29.032%		

In the theme of safety needs, nine items were obtained from the content analysis and the maximum eigenvalue is 9. Problem about clothing get caught in the wheels is mostly weighted in all the content and it is followed by the problem of pressure sore. Body coverage, bowel or bladder care, obesity-related health risks, preventing general injury and demand about the safety of the care-givers are ranked at the lowest weight at the same level.

In the aesthetic needs theme, four items were obtained from the content analysis and the maximum eigenvalue is 4. The demand of fashion and style weighs the most and the color weighs the least. Appearance is also mentioned frequently as a highly weighted topic.

In the expression needs, four items were obtained from the content analysis and the maximum eigenvalue is 4. The desire of social participation significantly weighs over the other items and the wish to change the stereotypes about disability and to be treated equally during social activities.

In the quality of life theme, four items were obtained from the content analysis and the maximum eigenvalue is 4. The needs of clothing to maintain emotional well-being is also significantly weighted and the desire about quality of life is least weighted. The other two items desired to be independent and wished to keep modesty and dignity are at the same level.

In the extrinsic attributes theme, four items were obtained from the content analysis and the maximum eigenvalue is 4. The needs of customization choices weighted the most, followed by price as the second weighted factor to influence the clothing choices. The least weighted item is online purchase.

All the AHP analysis with the eight themes has passed the consistency check and the weight showed significant differences, indicating that the calculated weights are consistent. In the next step, the overall data of eight themes has been also calculated using the component analysis to identify the general group of clothing needs, in order to further reduce the number of factors to illustrate the general clothing needs of wheelchair users. According to the result, a factor analysis based on the extraction method of Principal Component Analysis has been conducted. Firstly, the KMO measurement is $0.626 > 0.5$, indicating that the data is mediocre but acceptable for further analysis (see **Table 4**). The significance of Bartlett's test is $P = 0.000 < 0.001$, indicating the data can be applied into the principal component analysis.

The extraction results of the principle component analysis suggest that the eigenvalue of the first principle component in this study explains 41.115% of the total data variation. However, the accumulative eigenvalues of the top two

Table 4. KMO and bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.626
Bartlett's Test of Sphericity	Approx. Chi-Square	75.805
	df	28
	Sig.	0.000

principle components could explain 76.312% of the total data variation, reflecting relatively complete information of the data (See Table 5). Therefore, in this study, we finally extracted the top two principal components. A further information of component matrix and rotated component matrix is achieved using a mandatory extraction of principle component analysis.

Table 6 shows the component matrix and rotated component matrix of 2 principle components. It has shown the suggested correlation coefficient of the eight themes and the original variable. Since there is negative coefficient in the component matrix, which is not acceptable for interpretation, the coefficient in the rotated component matrix is selected to suggest the interpretation. The result shows that the relationship between the Functional needs (0.802), Fit attribute (0.868), Fabric and fiber attribute (0.923) and Extrinsic attribute (0.881) as the first principal component has a higher correlation, so the four themes could interpret more of the first principal component. On the other hand, Quality of life

Table 5. Total variance explained.

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.683	46.037	46.037	3.683	46.037	46.037	3.289	41.115	41.115
2	2.422	30.275	76.312	2.422	30.275	76.312	2.816	35.197	76.312
3	0.639	7.989	84.301						
4	0.558	6.969	91.271						
5	0.332	4.145	95.415						
6	0.168	2.104	97.519						
7	0.145	1.815	99.335						
8	0.053	0.665	100.000						

Table 6. The result of component matrix and rotated component matrix.

Component Matrix[a]			Rotated Component Matrix[b]		
	Component			Component	
	1	2		1	2
Functional needs	0.954	−0.020	Fabric and fiber	0.923	−0.032
Fabric and fiber	0.748	−0.543	Extrinsic Attributes	0.881	−0.008
Fit	0.735	−0.462	Fit	0.868	0.028
Extrinsic Attributes	0.726	−0.499	Functional needs	0.802	0.516
Aesthetic needs	0.694	0.298	Quality of life	−0.082	0.929
Safety	0.596	0.475	Expressive needs	−0.192	0.867
Expressive needs	0.325	0.827	Safety	0.229	0.727
Quality of life	0.451	0.816	Aesthetic needs	0.409	0.635

Extraction method: Principal component analysis. a. 2 components extracted. Rotation method: Varimax with Kaiser Normalization. b. Rotation converged in 3 iterations.

attribute (0.929), Expressive needs (0.867), and Safety (0.727) has a higher correlation with the second principal component, indicating that could interpret more of the second principal component.

Among all the themes, the aesthetic needs could be classified into both groups because it showed comparable coefficients in both factors; however, the aesthetic needs are considered as an abstract concept to the apparel selection, which is not closely related with the objective demands of clothing products. Therefore, even though the result has a slightly higher power in the first principal component, it is suggested to be classified with the expressive and quality of life factor according to the original meaning from the qualitative study. In summary, this step of exploration finally extracted two principal components. The functional needs, fit, fabric and fiber, and extrinsic needs reflect the physically assistive component in the clothing needs of wheelchair users and the aesthetic needs, expressive needs, quality of life, and safety reflect the psychologically assistive component. The extracted principal components explained 76.312% of the data variation cumulatively, reflecting the clothing needs of objective supports and subjective influence. The Safety theme maintains with the subjective influence component.

4. Discussion and Implication

In light of the proposed exploration framework, the distribution of items regarding clothing needs of wheelchair users is identified. The screening method is useful to find specific target while avoiding the bias in each individual study, so the general findings could reflect the concentrated problems and demands of wheelchair users about their clothing. A considerable topic about clothing needs is gathered in the analysis, but it is also necessary to further elaborate about why wheelchair users consider the topics are essential. Wheelchair users share similar clothing demands as in the researches about the general disabled persons, such as the challenges in dressing and undressing, more functional designs to solve the problems of disability, pattern adjustment and being capable to assist daily activities [6] [50]-[55]. For the disabled people, garment became not only a decoration but more like a tool to offer assistance that could make up the deficiency of the impairment, better to coordinate with the devices. But sometimes to solve one problem may lead to more special needs [56]. The needs of wheelchair users are relatively more critical because the wearers spend long time sitting and suffer more from the restriction of body movement. Coordination among all the solutions is an essential question for further study.

According to the result of the analysis, functional needs, including fit attributes, influenced the clothing choices of wheelchair users significantly. Even though fit attribute is widely recognized as a part of the functional support of the garment, in this study, it is separately listed out as an independent item because the concentrated responds from wheelchair users. In the functional needs of the clothing, dressing and undressing is the main challenge for wheelchair users. Due to the dysfunction of extremities, the wearers could hardly adapt to the common

design of the apparel. The issue is also related with the design of fastening as well as opening of the garment. Another item that most frequently mentioned is the regulation the body temperature. It affects the clothing choices of wheelchair users because disabled persons usually lack blood circulation and physical exercise, hence fail to adjust to the hot or cold temperature.

Moreover, there are clothing needs that discussed in a more complex way. Fit of the garment is one of the most discussed problems about current clothing for wheelchair users. The wearers are suffering from the ill-fitted clothes and it was found to be related with multiple body positions. One common problem is the design at the lower back of the wearers [3] [37] [40], because the tops and coats are shorter at the back than common need for a sitting person, leading to the edge scrolled and bunched up at the shoulder. The problem appeared together with the shortness of the trousers at the lower back and the waist. They share similar problem of failing to cover the back of the waist. The ill-fitted clothes happen where the body is bending and the body contour has more corves on wheelchair users. Such problem was also found at the stacked material of the front crotch, tightness at the knee, and shortness of the overall length of the trousers leading to the exposure of ankles [37] [48]. Researches about fitting simulation and body scan is designed to solve such problem [57] [58] [59] [60] [61], especially about the problem of unbalanced body measurement [8]. However, it is most connected with customization for individual cases, rarely related with a complete development of sizing system and pattern innovation for the sitting posture. What's more, the gap between the fit issue and customization is not merely about the body size. Customization of the apparel has been mentioned, as one of the promising solution to provide the garment for various demands [62] [63] [64]. However, according to the participants, they rarely have the choice of customized services because either the price exceeds their budget, or they need to pay extra cost looking for professionals to modify their newly-bought clothes. Such alteration is also a large consumption of time and money [3] [46].

In general, functional needs are still decisive among all the factors for wheelchair users when choosing the preferred apparel items. The clothing could still be improved by combining more effective solutions to solve multiple problems of functional requirements. Technology applied in the construction design, material development and sizing system is essential to form a comprehensive industry in the development of garment for the disabled population and wheelchair users. Sizing system is one of the major lacks in the garment industry, leading to the common situation of wheelchair users dressed in the ill-fitted apparel. Customization could offer fit garment to a certain type of customers, however, there is still a need of innovation of functional design of the clothing with general appeal to the disabled population.

During the content analysis, it was found that for a specific topic, there were opposite scenarios from different wearers so that their attitude could be different. For example, in the topic of regulating the body temperature, there are both

the need of keeping the body cooling during activity or in summer, and the need of maintaining the body warm in winter. Due to the poor blood circulation [7] of wheelchair users, they usually have a lower body temperature and challenge to adapt to changeable weather of the environment, therefore, keeping warmth is frequently mentioned as a key factor in their consideration [7] [40] [49]. On the contrary, some athletes using wheelchairs regularly have the sports activity, so the cooling function of their sportswear is counted as the priority. The divergent opinions also mentioned about the fastening design and closure design of the apparel. On one hand, it was highly suggested that the fastener accessories should be zippers and Velcro [41] [47], or snap fasteners [49], for the purpose to reducing the burden of manipulating the buttons by the wearer themselves. On the other hand, there was a voice about not using the Velcro because the wearer is afraid of the fastener could unexpectedly open causing the embarrassment. Similarly, wheelchair users demand an ingenious design of a quick-access opening [44], to relief the burden of dressing and undressing for both the wearer and care-giver. But it was found that a design with no closure is also welcomed because it eliminates the necessary to deal with any fasteners [39]. The divergence of clothing needs and preference added to the difficulty in clothing improvement. The requirements varied based on the original cause of disability and expectation of high quality of life. However, there are still similarities among a certain type of wheelchair users in the clothing needs. Classification of requirements is suggested for the improvement of clothing for the fact that categories simplify the targets on a specific domain of innovation. In this study, a method of general classification was provided, which could act as a starting point of further improvement.

Previous studies tried to identify the clothing needs of disabled based on Lamb & Kallal's [35] FEA (Functional, Expressive, Aesthetic) design framework [3] [65] [66]. Results revealed that aesthetic needs and expressive needs of wheelchair users became increasingly important to the wearers that the symbolic meaning of the appearance. Therefore, the social impact could never be neglected. This is with accordance with the findings about clothing needs of the general disabled [67] [68] [69], and also with the demand about the abstract meaning of garment specially for working [70] [71], social activities or cultural-related events [4] [72]. The desire of beauty and dignity is not only about the fashion and style of the items, but also being indifferent from the able-bodied persons, which is considered as a factor to influence the well-being of the feelings.

In this study, multiple psychological issues were found to be related with clothing, such as the impact of social participation, emotional well-being, attractiveness, and being treated equally, and they are closely related with the quality of life of wheelchair users. Basically, the embarrassment of being at a lower angle of eye contact during communication and being taking care of by other for long time makes wheelchair users feel guilty, therefore facing more interpersonal management at emotions [25]. Even though adaptive clothing has been explored

for the benefit of the wearers for the functional purpose [71] [73] [74], the different looks of the apparel might add to the stereotype of the public toward the disability, and the self-identity of the wearers themselves [48] [46]. A healthy emotional condition is not only required from the product of the apparel, but also from the public service of apparel purchase and acquisition [75] [76]. It is promising that previous studies have discussed about the possibility of joint solution of design, technology, production, and retailing to offer the satisfied apparel products to the disabled consumers [77] [78] [79] [80], but the findings also suggested the necessary of more attention to the aesthetic design of the apparel and the symbolic meanings to the wearers on the bases of functional approaches. Proper apparel market division for both the physical needs and psychological needs is helpful in the improvement of industry in regards to different types of customers. Meanwhile, the corresponding strategies to the markets connecting design, production, supply and promotion are also future directions in the research of the clothing industry for wheelchair users.

The selected literature in this study has revealed a general clothing needs of wheelchair users. Research methods using qualitative study dominated in most of the researches, including case study, group interview, questionnaire, and mixed-mode approach. Research areas covered the physical demand of the apparel, barriers in purchasing and acquisition, design solutions, specific types of garments such as sportswear, and more insights from wheelchair users about their inner feelings about clothing problems. Due to the limitation of the small number of participants in the study, the study could reflect limited insights among wheelchair users. For example, researches of Abraham-Muali *et al.* [39], Kabel [40], Thompson [46] and Kratz *et al.* [38] has interviewed less than 20 participants, which could lead to the bias in the final result. In addition, the Kabel [40] and Thompson [46] both looked into personal experiences of wheelchair users, with large percentage of information based on the subjective attitude, which might not be applied to the large group of population. Moreover, the aim of some studies was narrowed down for few specific topics, so perhaps failed to represent the general clothing needs of wheelchair users. The sportswear assessment in the study of Braganca *et al.* [37] is based on rugby, a sport activity that may not popular in other countries and areas. The clothing needs of performance in the sports could be different from the wearer for daily wears. The approaches of evaluating the theoretical framework and product critiques [8] [49] still need further exploration with more responds from the wheelchair user participants.

5. Conclusions

This study analyzed published research articles to clarify the fields of clothing needs of wheelchair users. A review framework was strictly designed, in order to obtain comprehensive information on current problems and challenges. We selected 16 articles for the review. The analysis results show that the findings of the

previous studies could be listed in multiple layers. Results from the content analysis of the 16 articles show that the extant studies cover eight prominent themes for further development of clothing for wheelchair users. The themes include attributes of functional needs, fit, fabric and fiber, aesthetic needs, expressive needs, safety, quality of life, and extrinsic needs. The component analysis proves that the two principle components, the physically assistant factor, and the mentally assist factor are influencing the clothing selection of wheelchair users.

Furthermore, there might be potential in the research direction of the development of clothing for wheelchair users. Firstly, the existing apparel achieved by the disabled customers has problems in both factors such as comfort, dressing and undressing, apparel measurement for sitting posture, tightness and length adjustment for bending joints, design of closure and fabric selection. The research of apparel technology and design could be applied to the garment in the real market at a low cost so that the customers could afford the product. Secondly, there are opposite attitudes of wheelchair users toward the challenges such as temperature regulation, adoption of wearable technology, and the choices between normal clothes and adaptive clothes. The findings suggested that future study could devote to explore a solution could benefit the wearers as well as reduce the extra burden of using the product. Moreover, the symbolic meaning and emotional well-being are found to be also related with the clothes. There is a lack of proper fashionable design that could adapt to professional or cultural occasions for the wheelchairs to enhance the social participation while maintaining their dignity. Future research could also explore the combination of aesthetic designs with the functional purpose that looks like normal garment rather than adaptive clothing.

Lastly, the method used in this study is following a mixed-mode exploration, trying to eliminate the bias in individual research to integrate a comprehensive review of all the relevant literature. The method could be extended to similar topics about the clothing needs of the disabled customers or promisingly larger areas. Despite the contribution, this study has some limitations. Due to the restriction of personnel, the content analysis is conducted by the author and multiple times of coding have been arranged to ensure any mistakes. In addition, the literature selected in the review is in a small amount. It is because of the difficulty in identifying published articles that consider both clothing needs and the targeted group of "wheelchair users". Nonetheless, result of sixteen articles is convincing in a short time span. In the future, a more complete review is also suggested under the research framework. Last, publications in languages other than English were excluded. Research on the clothing needs and development for wheelchair users can also be found in other languages.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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