# Ten Years of Health and Cosmetic Studies: Themes, Concepts and Relationships

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***Abstract*—To explore the intellectual structure of health and cosmetic research in the last decade, this study identified the most important publications and the most influential scholars as well as the correlations among these scholar's publications. In this study, bibliometric and social network analysis techniques are used to investigate the intellectual pillars of the health and cosmetic literature. By analyzing 95,367 citations of 1,914 articles published in SSCI journal in health and cosmetic area between 2007 and 2016, this study maps a knowledge network of health and cosmetic studies. The results of the mapping can help identify the research direction of health and cosmetic research and provide a valuable tool for researchers to access the literature in this area.**

***Index Terms*-citation, co-citation, health and cosmetic, social network, ethnic bulling, diffusion innovation**

## I. Introduction

The European Commission (EC) has accepted the Cosmetics Regulation by permitting the use of preservatives with significant sensitizing capacity in cosmetic products, as there is a reasonable demand for product preservation [1][2][3]. All cosmetic products impact the skin health, it is to be hoped in a positive manner, to improve skin health. The past decade has especially seen extensive research on health and cosmetic. Yet even though health and cosmetic has established itself as an academic discipline, its establishment has been a slow process because researchers in this area prefer to publish their best work in more established journals. Another major obstacle to the development of health and cosmetic lies in the subject's unusually high degree of interaction with other disciplines. This overlapping blurs the boundaries of health and cosmetic and as a result its distinct theoretical model and analytical tools are unjustly attributed to other competing fields. With limited resources contributing to the development of health and cosmetic, the cross-fertilization of ideas between scholars of health and cosmetic will be much more difficult to obtain. Consequently, while there is no doubt that there is an area or field of health and cosmetic, the question remains somehow unclear on what it is, how good its work is, and what are its prospects and needs for future development.

The aim of this study is to provide health and cosmetic researchers with a unique map to better understand health and cosmetic related publications and to provide a systematic and objective mapping of different themes and concepts in the development of health and cosmetic field. This study also attempts to help identify the linkage among different publications and confirm their status and positions in their contribution to the development of health and cosmetic field. The principal methods used are citation and co-citation analysis, social network analysis, plus a factor analysis which is performed to identify the invisible network of knowledge generation underlying the health and cosmetic literature.

## II. Studies of Academic Literature

There are a number of techniques that **c**an be used to study a body of literature. Most frequent is the simple literature review where a highly subjective approach is used to structure the earlier work. Objective and quantitative techniques have recently become popular with more databases available online for use. These techniques adopt author citations, co-citations, and systematic review [4] to examine the invisible knowledge network in the communication process by means of written and published works of a given field. These techniques are attractive because they are objective and unobtrusive [5].

Several studies have used the bibliometric techniques to study the literature of management research. For example, Wang [4] explored the intellectual structure and interdisciplinary breadth of nursing management in its early stage of development, using principle

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component analysis on an author co-citation frequency matrix; Gu [6] identified the most influential authors and studies in healthcare informatics field by using citation analysis; Ramos-Rodriguez and Ruiz-Navarro [7] examined the intellectual structure change of strategic management research by conducting a bibliometric study of the Strategic Management Journal; Raghupathi and Nerur [8] explored the research paradigms of health information systems research by applying factorial analysis techniques in an author co-citation study. Chan, Seow and Tam [9] used citations from accounting dissertations completed during 1999-2003 to provide a ranking of accounting journals. To the best of our knowledge, no similar study has been conducted on the current research of health and cosmetic. Therefore this study aims to fill a gap in health and cosmetic literature by applying citation and co-citation analysis to a representative sample of recent research on health and cosmetic collected by the Science Citation Index and Social Sciences Citation Index.

## III. Methodology

The citation data used in this study included journal articles, authors, publication outlets, publication dates, and cited references. Based on the objective of this study, the authors explored the intellectual structure of health and cosmetic between 2007 and 2016. This time period was chosen because contemporary health and cosmetic studies of the last five years represent the most update and probably also the most important research on health and cosmetic. Citation and co-citation analysis is the main method for this study. First, the databases were identified as the sources of health and cosmetic publications. Then data collection and analysis techniques were designed to collect information about topics, authors, and journals on health and cosmetic research.

In the second stage, the collected data were analyzed and systematized by sorting, screening, summing, subtotaling, and ranking. After a series of operations, key nodes in the invisible network of knowledge in health and cosmetic were identified and the structures developed. In the final stage, the co-citation analysis was used and the knowledge network of health and cosmetic was mapped to describe the knowledge distribution process in health and cosmetic area.

In this study, the Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) were used for analysis. The SCI and SSCI are widely used databases, which include citations published in over 33,000 world's leading scholarly journals. While there are arguments that other online databases might also be used for such analysis, using SCI and SSCI provided the most comprehensive and the most accepted databases of health and cosmetic publications.

Unlike other prior studies, the data used in this study were not drawn from journals chosen by peer researchers [20]. Instead, the entire databases of SCI and SSCI from 2007 to 2016 served as the universe for analysis. In order to collect the data, we used "key word" method which utilizes the SCI and SSCI databases key word search in article's title and abstract. Using "Health and cosmetic" as key word, this study collected 1,914 journal articles which further cited 95,367 publications as references. The cited references in these papers included both books and journal articles.

## IV. Results

### A. Citation Analysis

To identify the key publications and scholars that have laid down the ground work of health and cosmetic research, citation data were tabulated for each of the 1,914 source documents and 95,367 references using the *Excel* package. The citation analysis produced interesting background statistics, as shown in the following tables. Table 1 lists the most cited journals in health and cosmetic area in the decade years, among which *Journal of Agricultural and Food Chemistry*, *Plastic and Reconstructive Surgery*, and *Environmental Health Perspectives are* the top three most cited journals, followed by *Food Chemistry* and *Contact Dermatitis*. The general pattern of the most cited journals shows that health and cosmetic research features strategic, management and finance specific journals.

The most influential documents with the most citation and the most influential scholars were then identified by their total counts of citation within the selected journal articles. As shown in Table 2, the most cited health and cosmetic publication between 2007 and 2011 (the first five years ) was Klassen's paper *Patients' health related quality of life before and after aesthetic surgery* , followed by Rankin's paper *Quality-of-life outcomes after cosmetic surgery*, and Honigman's PAPER *A review of psychosocial outcomes for patients seeking cosmetic surgery* (see Table 2).

TABLE I. The Most Frequently Cited Journals: 2007- 2016

| Journals | Total Citations |
|---|---|
| Journal of Agricultural and Food Chemistry | 1454 |
| Plastic and Reconstructive Surgery | 1260 |
| Environmental Health Perspectives | 977 |
| Food Chemistry | 921 |
| Contact Dermatitis | 706 |
| Food and Chemical Toxicology | 613 |
| Environmental Science & Technology | 563 |
| Journal of the American Academy of Dermatology | 561 |
| Journal of Chromatography A | 493 |
| Toxicological Sciences | 473 |
| The New England Journal of Medicine | 447 |
| British Journal of Dermatology | 439 |

TABLE II. HIGHLY CITED DOCUMENTS: 2007- 2011

| Full Citation Index For Document | Total Citations |
|---|---|
| Klassen A, 1996, British Journal of Plastic Surgery, V49, P433 | 17 |
| Rankin M, 1998,Plastic and Reconstructive Surgery, V102, P2139 | 15 |
| Honigman RJ, 2004, Plastic and Reconstructive Surgery, V113, P1229 | 14 |
| Oberdorster G, 2005, Environmental Health Perspectives, V113, P823 | 14 |
| Ware JE, 1992, Medical Care, V30, P473 | 14 |
| Nel A, 2006, Science, V311, P622 | 12 |
| Ching S, 2003, Plastic and Reconstructive Surgery, V111, P469 | 11 |
| Hussain SM, 2005, Toxicology in Vitro, V19, P975 | 11 |
| Cole RP, 1994, British Journal of Plastic Surgery, V47, P117 | 10 |
| Didie ER, 2003, Journal of Womens Health & Gender-based Medicine, V12, P241 | 10 |
| Golden R, 2005, Critical Reviews in Toxicology, V35, P435 | 10 |
| Sarwer DB, 2003, Plastic and Reconstructive Surgery, V112, P83 | 10 |

For the second five years (2007- 2016), the most cited health and cosmetic publications were the same as in the first five years years. The third most cited was Darbre's paper *Paraben esters: review of recent studies of endocrine toxicity, absorption, esterase and human exposure, and discussion of potential human health risks* and Soni's paper *Safety assessment of esters of p-hydroxybenzoic acid (parabens)* and Darbre's paper *Concentrations of parabens in human breast tumours* (See Table 3).

TABLE III. HIGHLY CITED DOCUMENTS: 2012- 2016

| **Full Citation Index For Document** | **Total Citations** |
|---|---|
| Darbre PD, 2008,Journal of Applied Toxicology , V28, P561 | 29 |
| Soni MG, 2005, Food and Chemical Toxicology, V43, P985 | 28 |
| Darbre PD, 2004,Journal of Applied Toxicology, V24, P5 | 27 |
| Routledge EJ, 1998, Toxicology and Applied Pharmacology, V153, P12 | 25 |
| Oberdorster G, 2005, Environmental Health Perspectives, V113, P823 | 22 |
| Calafat AM, 2010, Environmental Health Perspectives, V118, P679 | 20 |
| Golden R, 2005, Critical Reviews in Toxicology, V35, P435 | 20 |
| Nel A, 2006, Science, V311, P622 | 19 |
| Ye XY, 2006, Environmental Health Perspectives, V114, P1843 | 18 |
| Schlumpf M, 2010, Chemosphere, V81, P1171 | 17 |
| Loretz LJ, 2005, Food and Chemical Toxicology, V43, P279 | 16 |
| Pusic AL, 2009, Plastic and Reconstructive Surgery, V124, P345 | 15 |

The top five most cited scholar between 2007 and 2011 (the first five years) were Klassen, Rankin, Honigman, Oberdorster and Ware (See Table 4). For the second five years, the status of the most important scholars changed. The top five most cited scholars were Darbre, Hargittai, Soni, Darbre, Routledge and Oberdorster (See Table 5). These scholars have the most influence in the development of health and cosmetic area and thus collectively define this field. Their contributions represent the focus of the main research in the field and thus give us an indication of the popularity of certain Health and cosmetic topics as well as their historical values.

TABLE IV. HIGHLY CITED AUTHORS: 2007- 2011

| Author | Frequency | Author | Frequency |
|---|---|---|---|
| Sarwer DB | 125 | Gulcin I | 38 |
| Phillips KA | 58 | Cash TF | 31 |
| Darbre PD | 53 | Klassen A | 30 |
| Oberdorster G | 51 | Ware JE | 30 |
| Hartung T | 48 | Donaldson K | 26 |

Although the citation analysis does not eliminate the bias against younger scholars, a paper-based ranking (as in Table 2 & 3) places more emphasis on the quality (as opposed to the quantity) of the documents produced by a given scholar than a ranking of authors based on the frequencies with which a particular author has been cited (as in Table 4 & 5). In addition, Table 2 and 3 represent the key research themes in a field and give us an indication of the popularity of certain Health and cosmetic topics. The readers can find high citations are associated to what can be termed the understanding of health and cosmetic as a distinct phenomenon. A comparison between Table 2 and 3 reveals some interesting patterns from the first five years (2007- 2011) to the second five years (2012- 2016). First, the top ten publication compared with the last five years only one published the same, showing the past decade health and cosmetics field development is very rapid. Second, on the one hand, the most cited publications in the first five years have relatively smaller number of citations, comparing with the publications in the second five years.

The gradual increase in the total citations supports the evolving process of health and cosmetic research as an academic field and the process of gaining more and more recognition in the literature. On the other hand, the most influential papers in the first five years and the second five years do change much. This indicates the development in health and cosmetic is rapid and a few classical works and influential authors still dominate the health and cosmetic research. More efforts and theoretical breakthrough are thus needed in order to further advance the development of health and cosmetic research.

TABLE V. HIGHLY CITED AUTHORS: 2012- 2016

| Author | Frequency | Author | Frequency |
|---|---|---|---|
| Darbre PD | 133 | Ye XY | 46 |
| Sarwer DB | 107 | Calafat AM | 45 |
| Oberdorster G | 57 | CASH TF | 38 |
| Warheit DB | 52 | Frederiksen H | 37 |
| Oishi S | 46 | Al-Saleh I | 35 |

### *B. Co-citation Analysis*

In this stage, data mapping was conducted and an intellectual structure of current Health and cosmetic studies was revealed. Co-citation analysis is a bibliometric technique that information scientists use to map the intellectual structure of an academic field. It involves counting documents from a chosen field - paired or co-cited documents. Co-citation analysis compiles co-citation counts in matrix form and statistically scales them to capture a snapshot at a distinct point in time of what is actually a changing and evolving structure of knowledge [19].

Co-citations were tabulated for each source documents by using the *Excel* package. Many of the authors had very few co-citations that were either unlikely to have had a significant impact on the development of the field or were too new to have had time to impact on the literature. To facilitate analyses and improve the probability of its success, it was made sure that all authors in the final set had at least 30 citations in the first ten years and 30 in the second five years. Based on the total number of citations in the selected journals, the top scholars were identified, and then a co-citation matrix was built before a pictorial map was drawn to describe the correlations among different scholars. In doing so, we were following the procedures recommended by White and Griffith [9].

Social network analysis techniques were used to graph the relationships in the co-citation matrix and identify the strongest links and the core areas of interest in health and cosmetic [15]. Figure 1 and Figure 2 show the core research themes in Health and cosmetic studies, based on sampled articles with links of greater than or equal to ten co-citations shown in the network. This is produced using UCINET software [2] and shows graphically the core areas of interest. Different shapes of the nodes result from performing a faction study of these authors. This method seeks to group elements in a network based on the sharing of common links to each other. The diagrams show that current research in health and cosmetic area is concentrating on the interactions of essential of technological diffusion, ethnic bulling, different cultural practices, diffusion innovation and technology adoption. The few scholars in Figure 1 and 2 with the most links (co-citation) are the super stars in health and cosmetic research. Their heavy citations and intensive interlinks with each other undoubtedly indicate their prestigious status in health and cosmetic research and their publications and research work collectively define the future research directions of health and cosmetic studies.

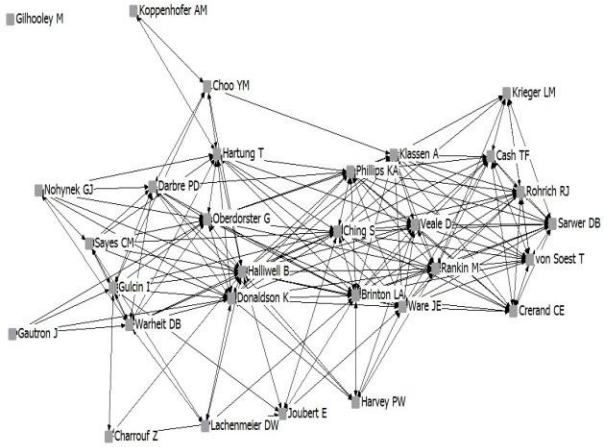


Figure 1. Key Research Themes in Health and Cosmetic (2007- 2011)

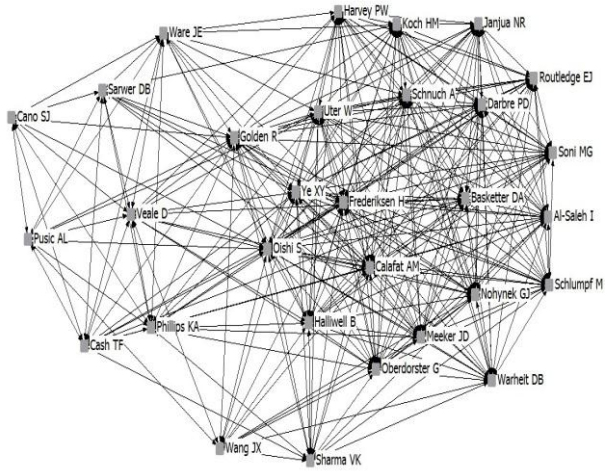


Figure 2. Key Research Themes in Health and Cosmetic (2012- 2016)

While the diagrams in Figure 1 and Figure 2 provide a clear picture, their foci are only on the very core areas and only a limited amount of information is revealed. By taking the co-citation matrix and grouping the authors using factor analysis of the correlations between the entries, we can determine which authors are grouped together and therefore share a common element. According to this, the closeness of author points on such maps is algorithmically related to their similarity as perceived by citers. We use r-Pearson as a measure of similarity between author pairs, because it registers the likeness in shape of their co-citation count profiles over all other authors in the set [22].

The co-citation correlation matrix was factor analyzed using varimax rotation, a commonly used procedure, which attempts to fit (or load) the maximum number of authors on the minimum number of factors. The diagonals were considered missing data and were applied the criterion of omitting the two cases [13].

Eight factors were extracted from the data in the first five years (2007- 2011) and together they explained over 73.9% of the variance in the correlation matrix. Table 6 lists the eight most important factors along with the authors that had a factor loading of at least 0.5. As is

usual in this type of analysis, authors with less than a 0.5 loading or with cross loadings were dropped from the final results [21]. We tentatively assigned names to the factors on the basis of our own interpretation of the authors with high loadings. Our interpretation of the analysis results is that health and cosmetic research in this period is composed of at least eight different sub-fields: endocrine disrupters, nanotoxicology, antioxidant and radical scavenging properties, estrogens and breast cancer risk, plastic surgery practices, endocrine toxicity, absorption, body Image and cosmetic and entomopathogenic nematodes. We made no attempts to interpret the remaining factors due to their small eigenvalues. They have also been excluded from Table 6.

Similarly, studies on health and cosmetic also clustered on different research themes between 2012 and 2016 and together they explained over 80.6% of the variance in the correlation matrix of the second five years, as pictured in Figure 2. Table 7 lists the eight most important factors along with the authors that had a factor loading of at least 0.5. We also tentatively assigned names to the factors on the basis of our own interpretation of the authors with high associated loadings. Our interpretation of the analysis results is that health and cosmetic research at this stage is also composed of at least four key subfields: antifungal and antiviral activities, free radicals and antioxidants, contact allergenic potency, mood disorders, psychology of cosmetic surgery, body images, breast surgery and nanotoxicology.

Figure 1 and Table 6 clearly indicated that the most influential authors in health and cosmetic studies between 2007 and 2011 clustered together. The first factor in Table 6 appears to define Endocrine disrupters and human health by Harvey, Warheit and Ware. Harvey and Darbre is suggested that body care cosmetics are a potentially important source of oestrogenic chemicals, and consequently that body care cosmetics may be associated with the rising incidence of breast diseas in women[16].

Factor 2 is defined by Nohynek, Hartung and Sayes, and appears to represent Nanotoxicology research. Many modern cosmetic or sunscreen products contain nano components. Nanoemulsions are transparent and have unique tactile and texture properties; nanocapsule, nanosome, noisome, or liposome formulations contain small vesicles (range: 50 to 5000 nm) consisting of traditional cosmetic materials. Nohynek et al., research suggests that vesicle materials may penetrate the stratum corneum of the human skin, but not into living skin [18]. Factor 3 represents Antioxidant and radical scavenging properties is defined by Gulcin, Joubert and Charrouf. All aerobic organismshave antioxidant defences, including antioxidant enzymes and antioxidant food constituents. Antioxidant compounds can scavenge free radicals and increase shelf life by retarding the process of lipid peroxidation, which is one of the major reasons for deterioration of food and pharmaceutical products during processing [19]. Factor 4 represents Estrogens and breast cancer risk by Brinton, Veale and Cash.

TABLE VI. AUTHOR FACTOR LOADINGS: 2007-2011

| Factor 1 | Variance | Factor 2 | Variance | Factor 3 | Variance | Factor 4 | Variance |
|---|---|---|---|---|---|---|---|
| Endocrine disrupters | 26.10% | Nanotoxicology | 15.80% | Antioxidant and radical scavenging properties | 10.80% | Estrogens and breast cancer risk | 5.30% |
| Harvey PW | 0.828 | Nohynek GJ | 0.974 | Gulcin I | 0.962 | Brinton LA | 0.915 |
| Warheit DB | 0.768 | Hartung T | 0.94 | Joubert E | 0.94 | Veale D | 0.833 |
| Ware JE | 0.763 | Sayes CM | 0.919 | Charrouf Z | 0.864 | Cash TF | 0.702 |
| von Soest T | 0.754 | Warheit DB | 0.823 | Choo YM | 0.818 | | |
| Veale D | 0.738 | Donaldson K | 0.806 | | | | |
| Sayes CM | 0.652 | Gautron J | 0.765 | | | | |
| Sarwer DB | 0.578 | Oberdorster G | 0.721 | | | | |
| Rohrich RJ | 0.502 | | | | | | |
| Factor 5 | Variance | Factor 6 | Variance | Factor 7 | Variance | Factor 8 | Variance |
| Plastic surgery practices | 5% | Endocrine toxicity, absorption | 3.70% | Body Image | 3.70% | Entomopathogenic nematodes | 3.50% |
| Krieger LM | 0.959 | Darbre PD | 0.723 | Sarwer DB | 0.787 | Koppenhofer AM | 0.726 |
| Rankin M | 0.718 | Lachenmeier DW | 0.679 | Phillips KA | 0.579 | Gilhooley M | 0.694 |
| | | | | Klassen A | 0.549 | | |

For the second five years, Figure 2 and Table 7 clearly indicated that the most influential authors in health and cosmetic studies between 2012 and 2016 also clustered together. The first factor in Table appears to define the Antifungal and antiviral activities is defined by Ye, Al-Saleh and Koch. Ye, Wang and Ng report the first isolation and characterization of a thaumatin-like protein, with inhibitory activity on fungal growth, from the legume (pod plus seeds) of the French bean [20].

Factor 2 is defined by Halliwell, Wang and Warheit, and appears to represent Free radicals, antioxidants, and human disease. Environmental radiation and physiological processes in the body cause free radicals to form. Scientific evidence may support the important role of free radicals in the development of some diseases. Free radicals can react with other molecules to cause cell damage or DNA mutation [21].

TABLE VII. AUTHOR FACTOR LOADINGS: 2012- 2016

| Factor 1 | Variance | Factor 2 | Variance | Factor 3 | Variance | Factor 4 | Variance |
|---|---|---|---|---|---|---|---|
| Antifungal and antiviral activities | 31.30% | Free radicals, antioxidants | 16.80% | Contact allergenic potency | 8.50% | Mood disorders | 6.80% |
| Ye XY | 0.928 | Halliwell B | 0.958 | Basketter DA | 0.928 | Golden R | 0.878 |
| Al-Saleh I | 0.903 | Wang JX | 0.935 | Uter W | 0.677 | Routledge EJ | 0.867 |
| Koch HM | 0.878 | Warheit DB | 0.935 | Schnuch A | 0.668 | Harvey PW | 0.862 |
| Frederiksen H | 0.852 | Sharma VK | 0.931 | | | Soni MG | 0.823 |
| Meeker JD | 0.844 | Nohynek GJ | 0.924 | | | Darbre PD | 0.641 |
| Janjua NR | 0.653 | | | | | Oishi S | 0.632 |
| | | | | | | Janjua NR | 0.627 |
| | | | | | | Schlumpf M | 0.537 |
| Factor 5 | Variance | Factor 6 | Variance | Factor 7 | Variance | Factor 8 | Variance |
| psychology of cosmetic surgery | 5.60% | Body images | 4.30% | Breast surgery | 3.80% | Nanotoxicology | 3.50% |
| Sarwer DB | 0.888 | Cash TF | 0.902 | Pusic AL | 0.936 | Oberdorster G | 0.709 |
| Veale D | 0.827 | Phillips KA | 0.874 | Ware JE | 0.663 | Cano SJ | 0.667 |
| Oishi S | 0.532 | | | | | | |

Factor 3 represents different Contact allergenic potency is defined by Basketter, Uter and Schnuch. The effective toxicological evaluation of skin sensitization

demands that potential contact allergens are identified and that the likely risks of sensitization among exposed populations assessed [22]. Factor 4 represents Mood disorders in the medically ill that is defined by Golden, Routledge and Harvey.

## V. Conclusion

The past decades years have seen extensive research on health and cosmetic. This study investigates health and cosmetic research using citation and co-citation data published in SCI and SSCI between 2007 and 2016. With a factor analysis of the co-citation data, this study maps the intellectual structure of health and cosmetic research, which suggests that the contemporary health and cosmetic research is organized along different concentrations of interests: Antifungal and antiviral activities, Free radicals, antioxidants, Contact allergenic potency and Mood disorders.

The mapping of the intellectual structure of health and cosmetic studies indicates that health and cosmetic has somehow created its own literature and that it has gained the reputation as a legitimate academic field, with health and cosmetic specific journals gaining the status required for an independent research field, such as the Journal of Agricultural and Food Chemistry and Plastic and Reconstructive Surgery. Given that the health and cosmetic is still young and our analysis has shown that it has an evolving structure, it is believed that health and cosmetic publication outlets will gain more popularity and prestige that is required to become a more prominent academic field when we learn more about current paradigms and the key research themes in health and cosmetic studies, how they relate, and what they stand for. With more scholars and more resources contributing to the health and cosmetic area, a better academic environment conducive for research ideas' cross fertilizing will be formed and health and cosmetic, as a field, will gain more momentum for further development,"

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