



# Research Trends on Doctors' Competencies in Korea Using Text Network Analysis

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We use the concept of the "doctor's role" as a guideline for developing medical education programs for medical students, residents, and doctors. Therefore, we should regularly reflect on the times and social needs to develop a clear sense of that role. The objective of the present study was to understand the knowledge structure related to doctors' job competencies in Korea. We analyzed research trends related to doctors' job competencies in Korea Citation Index journals using text network analysis through an integrative approach focusing on identifying social issues. We finally selected 1,354 research papers related to doctors' job competencies from 2011 to 2020, and we analyzed 2,627 words through data pre-processing with the NetMiner ver. 4.2 program (Cyram Inc., Seongnam, Korea). We conducted keyword centrality analysis, topic modeling, frequency analysis, and linear regression analysis using NetMiner ver. 4.2 (Cyram Inc.) and IBM SPSS ver. 23.0 (IBM Corp., Armonk, NY, USA). As a result of the study, words such as "family," "revision," and "rejection" appeared frequently. In topic modeling, we extracted five potential topics: "topic 1: Life and death in medical situations," "topic 2: Medical practice under the Medical Act," "topic 3: Medical malpractice and litigation," "topic 4: Medical professionalism," and "topic 5: Competency development education for medical students." Although there were no statistically significant changes in the research trends for each topic over time, it is nonetheless known that social changes could affect the demand for doctors' job competencies.

**Keywords:** Doctor's job competencies; Research trend analysis; Topic modeling

## Introduction

To become a doctor in South Korea, one must complete an educational curriculum at a medical school and pass the Korean National Licensing Examination for Physicians. The medical school education follows a competency-based curriculum that is grounded in the competencies society expects from doctors and is designed to equip graduates with the professional competencies necessary to treat patients from day one after graduation. Today's society requires a higher level of competencies from doctors than in the past and places a strong emphasis on

continuous competency development. This approach ensures that competencies are developed and expanded sequentially [1].

A doctor's competencies refer to what the doctor is able to do, how the doctor approaches his/her practice, and the doctor's role as a professional, and include knowledge, skills, and attitudes [2,3]. Competency-based education is typically structured in four steps: identifying the appropriate competencies, designing a training program, establishing suitable assessment methods, and setting minimum passing standards [4]. Because the competencies required of doctors can vary significantly depending on the clinical, cultural, and geographic context [5], determining core competencies is a critical step in planning competency-based education. In Canada, the CanMEDS (Canadian Medical Education Directions for Specialists) 2000 project outlined the general competencies needed by healthcare professionals [6], and in the United States, the Accreditation Council for Graduate Medical Education's six core competencies refer to a doctor's role as a medical expert, communicator, collaborator, health advocate, manager, scholar, and professional [7]. In the United Kingdom, common competencies for medical students are detailed in Tomorrow's Doctors, and for specialties in Good Medical Practice [8].

In Korea, research on competency development has been ongoing

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since 2007, initiated by a study on the common curriculum for medical specialties conducted by the Planning, Research, and Development Committee of the Korean Institute of Medical Education and Evaluation [1]. The virtues and competencies required of doctors in Korea were recently updated in “Korean Doctor’s Role 2022,” which delineated 54 roles and regulations across five domains: patient care, communication and cooperation, social accountability, professionalism, and education and research [9]. Patient care encompasses medical knowledge, medical care competency, and patient safety competency. Communication and collaboration involve interactions with patients and their families (guardians), as well as with health workers and the broader society. Social accountability covers public and international health activities, along with participation in healthcare policy. Professionalism is characterized by ethical practice and autonomy, patient-doctor relationships, self-regulation led by professionals, and competencies in professionalism and self-management. Education and research are defined by their respective competencies. The framework of the Korean Medical Competencies serves as a guideline for both basic medical education programs and postgraduate training. Therefore, it is essential that these guidelines continue to be updated to reflect the evolving context of Korean society and to align with future developments [10]. Analyzing research trends is one method of identifying issues related to medical competencies in Korea.

Research trend analysis is a method used to identify societal needs, and to date, it has primarily been conducted through systematic reviews [11-13]. However, systematic reviews involve categorizing and analyzing past studies based on the knowledge and insights of a limited number of experts. The diversity of concepts and contexts in the literature can make it challenging to set criteria without introducing subjectivity, which in turn narrows the scope of the analysis [14,15]. To address these limitations and derive more cohesive and structured outcomes, text network analysis on the basis of text mining has increasingly been employed.

Text network analysis offers the advantage of not being constrained by specific tools, allowing for the systematic organization and explanation of knowledge structures through the derivation of features in the form of a connection network [16]. It also facilitates an intuitive understanding of context by identifying influential keywords within a large corpus of text and examining the relationships between these keywords [17]. In addition, topic modeling yields comprehensive insights by uncovering latent topics within the text and analyzing the associations and distributions of each topic. This enables the identification of key topics and their interrelationships at a micro level, as well as the discernment of the evolution and context of key topics and the trends of topics over

time at a macro level [18,19]. Analyzing research trends through text network analysis can aid in comprehending the progression of research over time, future issues, and the interconnectedness of concepts, which can help organize the context of the knowledge structure.

Therefore, this study aimed to extract keywords from research on doctors’ job competencies in Korea over the past decade using text network analysis and to analyze the interconnections among these keywords. Furthermore, we examine the primary topics addressed in the research on doctors’ job competencies in Korea and explore research trends by tracking how each topic has evolved over time. This analysis will assist in proposing future research topics and directions for the advancement of doctors’ job competencies in Korea.

## Methods

### 1. Study design

Text network analysis and topic modeling techniques were used to analyze domestic research trends related to doctors’ job competencies. A variety of software tools are available for text network analysis, including NetMiner, NodeXL, UCINET, and NetDraw. For our study, we selected NetMiner ver. 4.2 (Cyram Inc., Seongnam, Korea), a social network analysis program known for its interactive data analysis and visualization capabilities, which also allows for representation as a 2-mode network [20]. Initially, we identified and extracted the articles for analysis. We then explored the relationships between the primary keywords using frequency and centrality analyses. This process enabled us to identify the main topics of research. Subsequently, we examined the evolution of these topics over the past 10 years, analyzing how they have been addressed in scholarly work.

### 2. Data collection

Using Biblio Data Collector in NetMiner ver. 4.2 (Cyram Inc.), we conducted a search for studies published between 2011 and 2020 that are listed in the Korea Citation Index. Our search criteria included the keywords “doctor’s job competencies,” “doctor’s competency,” “doctor’s professionalism,” “doctor’s role,” “doctor’s accountability,” “doctor’s job,” and “medical care professionalism” in the title and abstract. We initially extracted a total of 1,945 articles. After excluding duplicates and off-topic studies, we narrowed the selection down to 1,885 articles for analysis.

### 3. Pre-processing

We extracted 6,694 words using the refinement and morphological analysis functions of NetMiner ver. 4.2 (Cyram Inc.), and we performed pre-processing to organize them into analyzable data. First, we

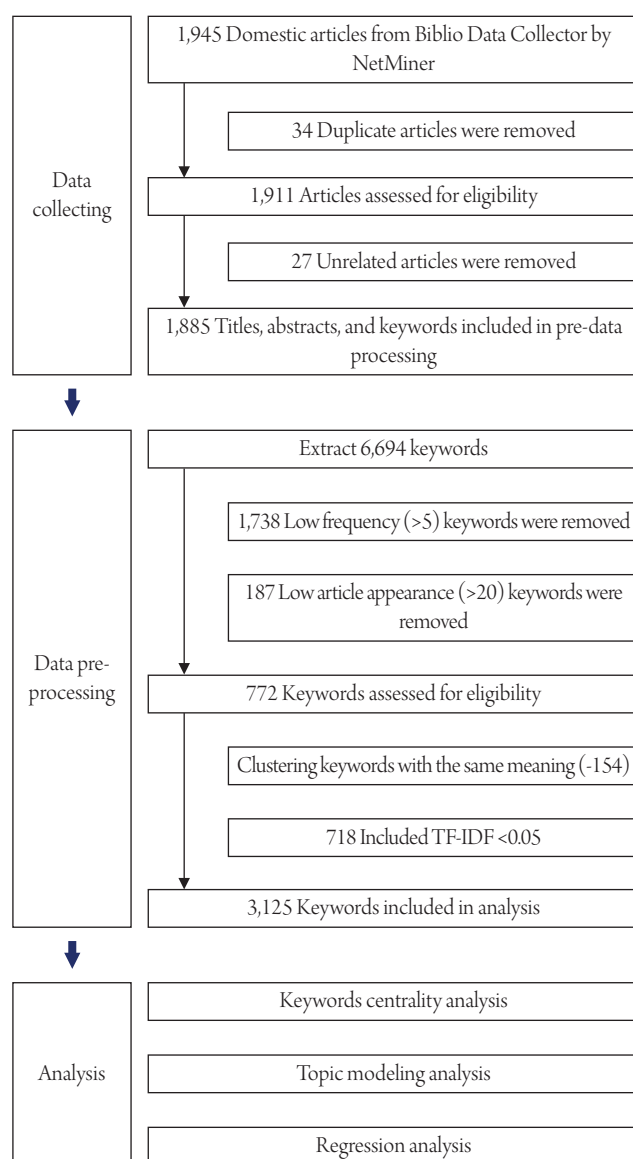
removed conjunctions, prepositions, adverbs, and investigations, retaining only nouns. We also discarded keywords that appeared fewer than 5 times across all articles. Subsequently, we excluded words that were not present in at least 20 articles within the study or were deemed common, frequently occurring across all documents, as indicated by a term frequency-inverse document frequency (TF-IDF) of less than 0.05. This process yielded a refined dataset of 3,125 words.

#### 4. Data analysis

First, we conducted a centrality analysis of the extracted keywords, utilizing both keyword frequency and TF-IDF. A TF-IDF value approaching 0 indicates a word's commonality across all documents. Consequently, we eliminated words with low TF-IDF values to isolate significant terms that encapsulate the core meanings within the documents [21]. Subsequently, we pinpointed key nodes by evaluating degree centrality, closeness centrality, and betweenness centrality. Degree centrality assesses a keyword's influence based on the number of direct connections it has with other keywords. In contrast, betweenness centrality gauges the extent to which a keyword acts as a bridge between two other keywords, with higher centrality reflecting more frequent appearances on the shortest paths between other nodes. Keywords with high betweenness centrality are pivotal in controlling the flow of information and exert a substantial impact on the network's overall connectivity and information flow. To visually interpret the positions and relationships among keywords, we employed NetMiner ver. 4.2 (Cytam Inc.), applying a spring method for visualization. For our second step, we utilized the latent Dirichlet allocation algorithm within the NetMiner ver. 4.2 plugin (Cytam Inc.) to identify latent topics through topic modeling, which analyzes word associations. We set the TF-IDF threshold at 0.5 and the minimum word length at two characters. The silhouette coefficient, with parameters  $\alpha = 0.3$  and  $\beta = 0.02$ , helped us determine that the optimal number of topics was five. The silhouette coefficient evaluates the quality of clustering, with values nearing 1 signifying more distinct clustering. Effective clustering indicates that clusters are well separated from one another and that data points within the same cluster are closely related [22].

The number of main keywords for each topic derived from the topic modeling results was set to 15. We then conducted a two-mode social network analysis to examine the network structure of the relationships between words within each topic. Next, we analyzed the temporal evolution of topics by dividing the timeline into four periods: 2011–2013, 2014–2016, 2017–2019, and 2020–2021. To identify patterns in the fluctuation of topics over these periods, we conducted a linear regression analysis using the period as the independent variable and the pro-

portion of each topic within the total documents as the dependent variable. Based on the direction and significance of the regression coefficients, we classified the topics into four categories: hot (+,  $p < 0.05$ ), warm (+,  $p > 0.05$ ), cool (–,  $p > 0.05$ ), and cold (–,  $p < 0.05$ ). “Hot topics” indicated areas with growing research interest, while “cold topics” pointed to those with waning interest. Additionally, trends that were not statistically significant but still exhibited an upward or downward trajectory were labeled as “warm topics” and “cool topics,” respectively. The comprehensive methodology for analyzing the results is shown in Figure 1.



**Figure 1.** Research flow. TF-IDF, Term Frequency-Inverse Document Frequency.

## Results

### 1. Key words from research on Korean doctors' job competencies

#### 1) Key words

The top 20 words with the highest simple co-occurrence in studies of doctors' job competencies conducted between 2011 and 2020 are listed in Table 1. The word "family" appeared with a frequency of 651, followed by "revise" at 558, "denial" at 545, and "health" at 517. The most frequently appearing words in these studies also followed a similar order, with "health," "family," and "revision" being the most common.

#### 2) Centrality analysis

As shown in Table 2, the centrality analysis of the main keywords in studies on doctors' job competency published in Korean journals from 2011 to 2021 revealed that both connection centrality and proximity centrality were higher for the terms "life" (0.778, 0.818), "nation" (0.736, 0.791), "informed" (0.722, 0.783), "license restriction" (0.708, 0.774), and "rights" (0.708, 0.774). Additionally, mediational centrality was observed in descending order for "life" (0.019), "level" (0.018), "nation" (0.018), "informed" (0.017), "ethics" (0.015), and "effect" (0.015). The centrality network map illustrates that the words "human," "rights," "legislation," "life," "guarantee," and "law" are positioned at the center of

the network and are represented by large nodes, indicating high centrality (Figure 2).

### 2. Topic modeling

The silhouette coefficient was derived to determine the optimal number of topics for a study on Korean doctors' job competencies. The analysis indicated that five topics were most suitable, with a silhouette score of 0.737. As shown in Table 3, the key words that emerged in Topic 1 were "life," "death," "rights," "human," "diagnosis," and "suicide," which we labeled "life and death in medical situations." Topic 2 was named "medical care practice under the Medical Act," with the following keywords: "remote," "medical law," "ruling," "restriction," "license," and "amendment." Topic 3 was labeled "medical malpractice and litigation," with the following keywords: "naming," "description," "damages," "compensation," "interruption," and "violation." Topic 4 was labeled "medical professionalism," with key words such as "autonomy," "state," "ethics," "regulation," "principles," and "surgery." Topic 5 was named "competency development education for medical students," with key words such as "learning," "student," "university, program," and "performance." Each topic contained 336, 306, 457, 307, and 548 studies. The network of 15 key words per topic was visualized as a spring topic-keyword map, and as shown in Figure 3, topics 3 and 4 were connected around the keyword "malpractice," and topics 4 and 5 were connected around the keyword "level."

**Table 1.** High-ranking keywords by frequency in research

| No. | Keyword                                            | Frequency | Appearance frequency in research |
|-----|----------------------------------------------------|-----------|----------------------------------|
| 1   | Family                                             | 651       | 315                              |
| 2   | Revision                                           | 558       | 335                              |
| 3   | Denial                                             | 545       | 218                              |
| 4   | Health                                             | 517       | 398                              |
| 5   | The Act on Life-Sustaining Treatment Determination | 464       | 154                              |
| 6   | Contract                                           | 450       | 174                              |
| 7   | Malpractice                                        | 392       | 258                              |
| 8   | Instruction                                        | 372       | 275                              |
| 9   | Nation                                             | 366       | 241                              |
| 10  | Rights                                             | 356       | 254                              |
| 11  | Regulation                                         | 349       | 148                              |
| 12  | Prohibition                                        | 333       | 195                              |
| 13  | Supreme court                                      | 294       | 127                              |
| 14  | College                                            | 273       | 250                              |
| 15  | Consent                                            | 263       | 147                              |
| 16  | Robot                                              | 227       | 159                              |
| 17  | Medical license                                    | 211       | 161                              |
| 18  | Objectives                                         | 209       | 125                              |
| 19  | Reparation                                         | 189       | 141                              |
| 20  | Legal                                              | 174       | 101                              |

**Table 2.** High-ranking keywords by degree centrality, closeness centrality, and betweenness centrality

| No. | Degree centrality    |       | Closeness centrality |       | Betweenness centrality |       |
|-----|----------------------|-------|----------------------|-------|------------------------|-------|
|     | Keywords             | Value | Keywords             | Value | Keywords               | Value |
| 1   | Life                 | 0.778 | Life                 | 0.818 | Life                   | 0.019 |
| 2   | Nation               | 0.736 | Nation               | 0.791 | Level                  | 0.018 |
| 3   | Informed             | 0.722 | Informed             | 0.783 | Nation                 | 0.018 |
| 4   | License restrictions | 0.708 | License restrictions | 0.774 | Informed               | 0.017 |
| 5   | Rights               | 0.708 | Rights               | 0.774 | Ethics                 | 0.015 |
| 6   | Medical personnel    | 0.694 | Medical personnel    | 0.766 | Effect                 | 0.015 |
| 7   | Principle            | 0.681 | Principle            | 0.758 | License restrictions   | 0.015 |
| 8   | Health insurance     | 0.681 | Health insurance     | 0.758 | Permissible range      | 0.014 |
| 9   | Permissible range    | 0.667 | Permissible range    | 0.750 | Rights                 | 0.014 |
| 10  | Human                | 0.667 | Human                | 0.750 | Human                  | 0.013 |
| 11  | Level                | 0.667 | Level                | 0.750 | Principle              | 0.013 |
| 12  | Legal                | 0.667 | Legal                | 0.750 | Autonomy               | 0.013 |
| 13  | Ethics               | 0.653 | Ethics               | 0.742 | Medical personnel      | 0.013 |
| 14  | Effect               | 0.639 | Effect               | 0.735 | Health insurance       | 0.012 |
| 15  | Life-sustaining      | 0.639 | Life-sustaining      | 0.735 | Safety                 | 0.012 |
| 16  | Constitution         | 0.625 | Constitution         | 0.727 | Environment            | 0.012 |
| 17  | Autonomy             | 0.625 | Autonomy             | 0.727 | Legal                  | 0.011 |
| 18  | Safety               | 0.625 | Safety               | 0.727 | Risk                   | 0.010 |
| 19  | Infringement         | 0.611 | Infringement         | 0.720 | Healthcare             | 0.009 |
| 20  | Lawmaking            | 0.611 | Lawmaking            | 0.720 | Revision               | 0.009 |

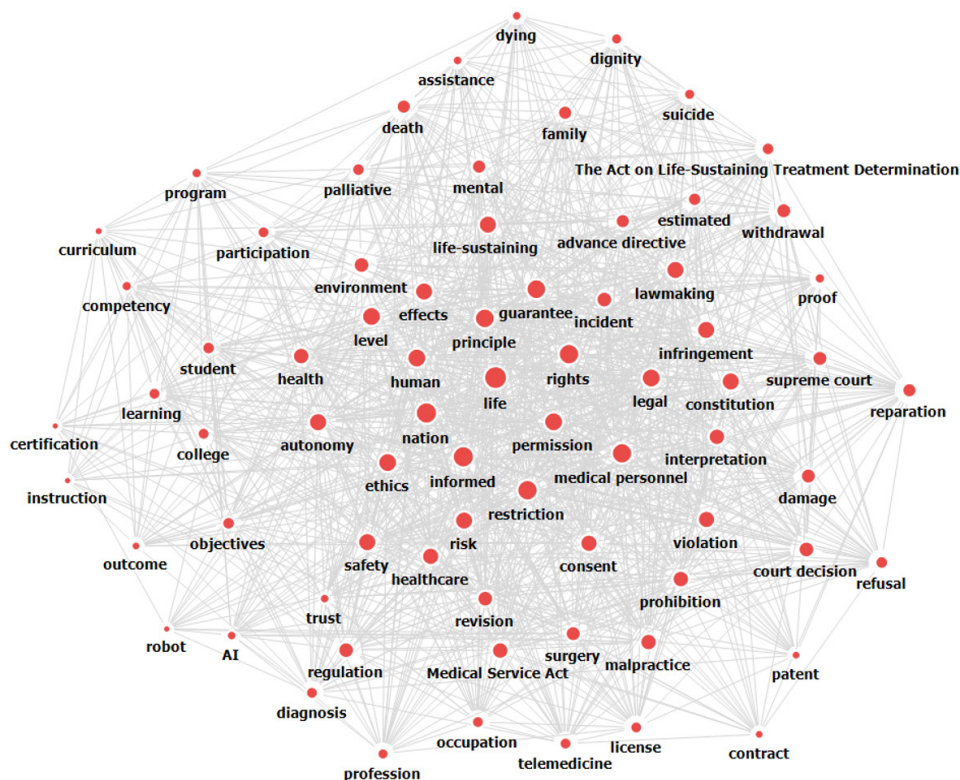
**Figure 2.** Centrality network map.

Table 3. Core keywords and number of documents by topic

| Rank      | Topic 1: life and death in medical situations | Topic 2: medical practice under the Medical Act | Topic 3: medical malpractice and litigation        | Topic 4: medical professionalism | Topic 5: competency development education for medical students |
|-----------|-----------------------------------------------|-------------------------------------------------|----------------------------------------------------|----------------------------------|----------------------------------------------------------------|
| 1st       | Life                                          | Telemedicine                                    | Life-sustaining                                    | Autonomy                         | Learning                                                       |
| 2nd       | Death                                         | Medical Service Act                             | Informed                                           | Nation                           | Student                                                        |
| 3rd       | Rights                                        | Court Decision                                  | Damage                                             | Ethics                           | College                                                        |
| 4th       | Human                                         | Restriction                                     | Reparation                                         | Regulation                       | Program                                                        |
| 5th       | Diagnosis                                     | License                                         | Withdrawal                                         | Principle                        | Outcome                                                        |
| 6th       | Suicide                                       | Revision                                        | Violation                                          | Surgery                          | Level                                                          |
| 7th       | Patent                                        | Permission                                      | Infringement                                       | AI                               | Safety                                                         |
| 8th       | Dignity                                       | Medical personnel                               | The Act on Life-Sustaining Treatment Determination | Risk                             | Objectives                                                     |
| 9th       | Palliative                                    | Refusal                                         | Malpractice                                        | Profession                       | Environment                                                    |
| 10th      | Assistance                                    | Prohibition                                     | Family                                             | Occupation                       | Professor                                                      |
| Documents | n=336                                         | n=306                                           | n=457                                              | n=307                            | n=548                                                          |

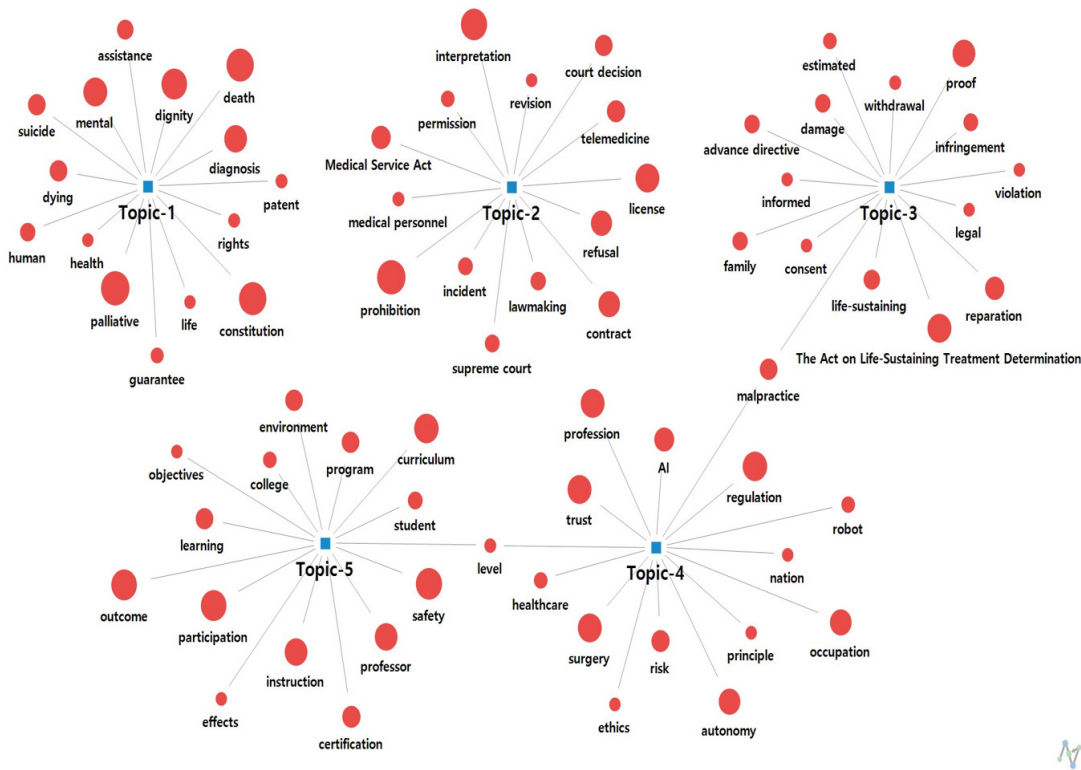


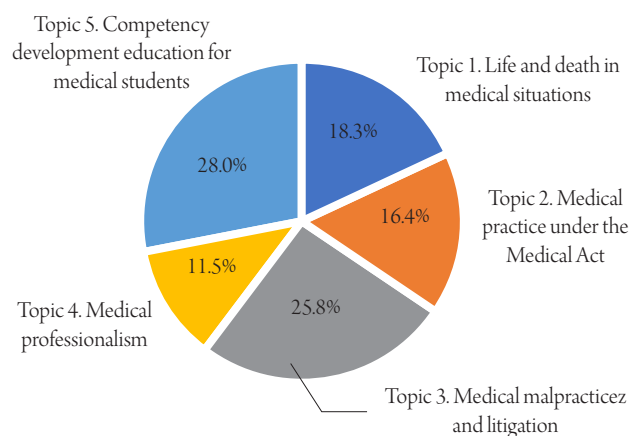
Figure 3. Topic modeling network: a topic-keyword map.

3. Trends in doctor's job competencies over time

1) Research trends by year

As shown in Figure 4, the most frequently studied topics in Korean research on doctor's competencies were Topic 5 ("competency devel-

opment education for medical students") (28%), Topic 3 ("medical malpractice and litigation") (25.8%), and Topic 1 ("life and death in medical situations") (18.3%). In other words, over the past decade, Korean researchers have been most interested in education for medical professionals in their research on doctors' competencies. The highest



**Figure 4.** Proportional distribution of research on the 5 topics for 10 years.

proportion of studies (16.1%) was published in 2019 (Table 4). Looking at the yearly trends by topic, Topic 1 (16.8%) and Topic 3 (20.2%) had the highest number of publications in 2019, while Topic 2 had the highest number of publications in 2016 (22.3%), Topic 4 in 2018 (22.6%), and Topic 5 in 2017 (17.8%).

## 2) Research trends over time

Upon analyzing the research trends over time (Figure 5), we found that from 2011 to 2016, corresponding to the first and second periods, Topic 5 (“education for healthcare professionals”) was the most studied topic, accounting for 39.3% and 31.8% of studies, respectively, while from 2017 to 2019 and 2020 to 2021 (i.e., the third and fourth periods), Topic 3 (“medical malpractice and litigation”) was the most studied topic, in 27.5% and 25.1% of studies, respectively. As time passes from first to fourth periods, the proportion of studies dealing with Topic 5 (“education for medical professionals”) decreased from 39.3% to 19.3%, while that of studies on Topic 4 (“medical professionalism”) increased from 7.9% to 16.3%. To characterize the topics over time, we ran a linear regression analysis, and as shown in Table 5, all of the regression coefficients were negative and statistically insignificant, corresponding to “cool topics.” This shows that the number of studies per topic gradually decreased as time increased, but the difference was not statistically significant.

## Discussion

Using text network analysis and topic modeling, we analyzed research trends related to doctors’ job competency in studies published in Korea from 2011 to 2020.

**Table 4.** Number of studies on the five topics by year and period

| Topic | 1st period |           |          |            |           | 2nd period |            |            |            |            | 3rd period |            |            |           |            | 4th period    |      |       |      |       |
|-------|------------|-----------|----------|------------|-----------|------------|------------|------------|------------|------------|------------|------------|------------|-----------|------------|---------------|------|-------|------|-------|
|       | 2011       | 2012      | 2013     | Total      | 2014      | 2015       | 2016       | Total      | 2017       | 2018       | 2019       | Total      | 2020       | 2021      | Total      | 2022          | 2023 | Total | 2024 | Total |
| 1     | 4 (1.2)    | 26 (7.5)  | 19 (5.5) | 49 (14.2)  | 26 (7.5)  | 32 (9.3)   | 23 (6.7)   | 81 (23.5)  | 42 (12.2)  | 36 (10.4)  | 58 (16.8)  | 136 (39.4) | 50 (14.5)  | 29 (8.4)  | 79 (22.9)  | 345 (100.0)   |      |       |      |       |
| 2     | 1 (0.3)    | 9 (2.9)   | 4 (1.3)  | 14 (4.5)   | 18 (5.8)  | 4 (1.3)    | 69 (22.3)  | 91 (29.4)  | 40 (12.9)  | 49 (15.9)  | 52 (16.8)  | 141 (45.6) | 32 (10.4)  | 31 (10.0) | 63 (20.4)  | 309 (100.0)   |      |       |      |       |
| 3     | 13 (2.7)   | 38 (7.8)  | 12 (2.5) | 63 (13.0)  | 38 (7.8)  | 26 (5.3)   | 38 (7.8)   | 102 (21.0) | 78 (16.0)  | 54 (11.1)  | 98 (20.2)  | 230 (47.3) | 69 (14.2)  | 22 (4.5)  | 91 (18.7)  | 486 (100.0)   |      |       |      |       |
| 4     | 1 (0.5)    | 10 (4.6)  | 8 (3.7)  | 19 (8.8)   | 10 (4.6)  | 3 (1.4)    | 18 (8.3)   | 31 (14.3)  | 32 (14.7)  | 49 (22.6)  | 27 (12.4)  | 108 (49.8) | 35 (16.1)  | 24 (11.1) | 59 (27.2)  | 217 (100.0)   |      |       |      |       |
| 5     | 48 (9.1)   | 27 (5.1)  | 19 (3.6) | 94 (17.8)  | 27 (5.1)  | 23 (4.4)   | 92 (17.4)  | 142 (26.9) | 94 (17.8)  | 59 (11.2)  | 69 (13.1)  | 222 (42.0) | 20 (3.8)   | 50 (9.5)  | 70 (13.3)  | 528 (100.0)   |      |       |      |       |
| Total | 67 (3.6)   | 110 (5.8) | 62 (3.3) | 239 (12.7) | 119 (6.3) | 88 (4.7)   | 240 (12.7) | 447 (23.7) | 286 (15.2) | 247 (13.1) | 304 (16.1) | 837 (44.4) | 206 (10.9) | 156 (8.3) | 362 (19.2) | 1,885 (100.0) |      |       |      |       |

Values are presented as number (%).

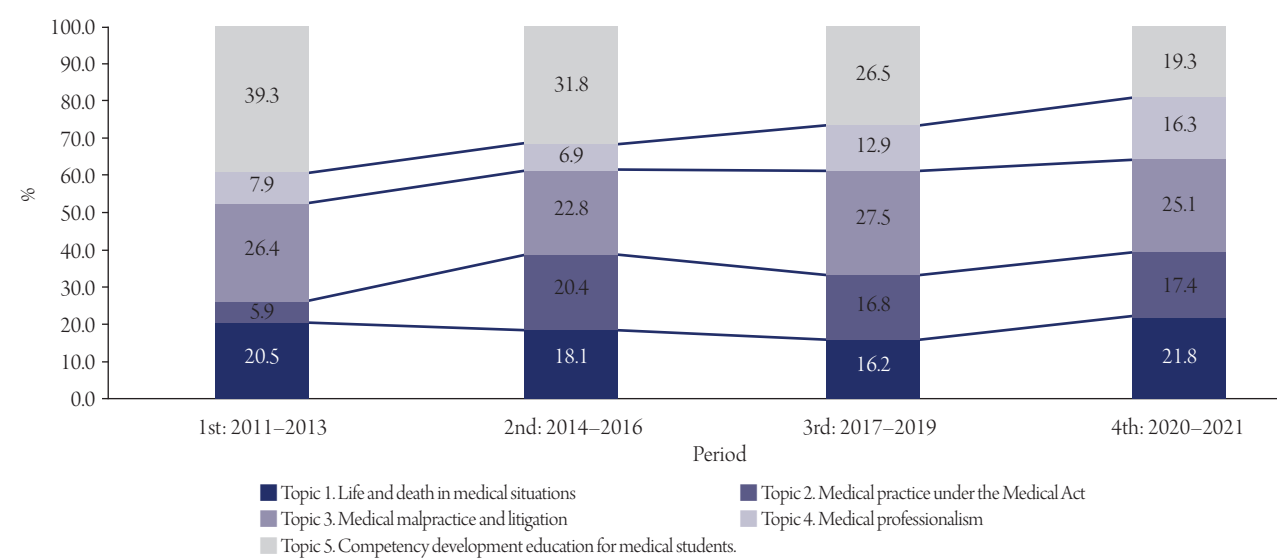


Figure 5. Topic trends during the study period.

Table 5. Regression analysis results for each topic

| Topic   | B      | $\beta$ | t-value | p-value | Durbin Watson | Type         |
|---------|--------|---------|---------|---------|---------------|--------------|
| Topic 1 | -0.500 | -0.164  | -0.288  | 0.792   | 3.010         | 'Cool topic' |
| Topic 2 | -1.900 | -0.878  | -3.181  | 0.050   | 3.107         | 'Cool topic' |
| Topic 3 | -0.100 | -0.029  | -0.049  | 0.964   | 3.247         | 'Cool topic' |
| Topic 4 | -1.000 | -0.606  | -1.321  | 0.278   | 2.267         | 'Cool topic' |
| Topic 5 | -0.500 | -0.154  | -0.269  | 0.805   | 3.372         | 'Cool topic' |

The most frequently occurring words in studies of doctors’ job competencies published in Korea from 2011 to 2021 were “family,” “revision,” “denial,” and “health.” These terms were prevalent across multiple studies. The word “family” appeared most often in discussions about disclosing medical errors to patients and their families, the doctor’s duty to provide explanations to patients and their families, obtaining consent, and the treatment of individuals without family ties. “Revision” was commonly associated with changes to healthcare legislation, while “denial” frequently arose in the context of doctors’ refusal to provide treatment and patients’ legal right to refuse treatment. The term “health” was used in various contexts, including community and patient health, the right to health, health-related issues, and the National Health Insurance Act. These findings indicate that legal considerations regarding the rights of patients and doctors in medical contexts are a dominant theme. The results align with those from the centrality analysis.

The terms that exhibited significant centrality in both connection and proximal centrality analyses included “life,” “nation,” “informed,” “restriction,” and “right.” Additionally, the words that served as key mediators in the relationships between other terms were “life,” “level,” “nation,”

“informed,” and “ethics.” When examining the terms with high connection and proximity centrality, “life” was predominantly associated with discussions on the protection of patient life, legal regulations concerning life, and bioethical principles. The term “nation” was frequently used in the context of national health and welfare, philosophical considerations at the national level, laws, and policies, as well as to highlight the variances among different countries. The word “informed” was primarily used in reference to the obligation of physicians to provide clear explanations of their medical practices.

In other words, the keyword network analysis showed that discussions about national policies concerning the principle of respect for life and the legal obligations of physicians in medical contexts are prevalent. This finding aligns with the “Korean Doctor’s Role, 2022” which highlights the importance of patient safety competencies and social responsibilities, including effective communication and collaboration with society, engagement in public and international health initiatives, and involvement in healthcare policy [9]. This trend may be due to the focus of the Korean journals examined in this study, which predominantly address healthcare-related laws and policies, such as those found in ‘The

Korean Society of Law and Medicine,' *The Korean Journal of Medical Ethics*, 'The Korea Consumer Law,' *The Asia Pacific Journal of Health Law & Ethics*. Furthermore, the exploration of doctors' legal responsibilities is not unique to Korea. International studies, such as those on a national palliative care competency framework [23] and the ethical and legal considerations surrounding end-of-life care in intensive care units [24], also address these issues.

Second, topic modeling identified a total of five distinct topics. Topic 1's primary keywords included "life," "death," "rights," "human," and "diagnosis." This topic predominantly comprised studies that sought to delineate and educate individuals about the varying perceptions and concepts encountered in medical contexts. Topic 2 featured terms such as "remote," "medical law," "judgment," "restriction," and "license." It focused on discussions regarding the criteria for limiting physicians' liability, the restriction of medical care, and the competition arising from legal judgments within the realm of medical law, as well as the legitimacy of doctor-patient interactions via telemedicine under existing telemedicine regulations. Topic 3 encompassed keywords like "life-sustaining," "informed," "damages," and "compensation." It revolved around legal precedents and cases involving the withdrawal of life-sustaining treatment as stipulated by the Act on Decisions on Life-Sustaining Treatment for Patients enacted in February 2018, in addition to liability issues related to damages for failing to provide adequate explanations or for medical malpractice. Topic 4 addressed the professional self-regulation of physicians, as well as the variations in national policies and principles. Lastly, Topic 5 examined the outcomes of various educational programs for university students at medical schools and hospitals.

After identifying keywords and original articles, the topics were organized as follows: life and death in medical situations, medical practice under the Medical Act, medical malpractice and litigation, medical professionalism, and competency development education for medical students. It is apparent that topics 1, 2, and 3 primarily involve discussions about medical law, while topics 4 and 5 pertain to medical education. Concurrent with this study, there were 745 international studies indexed in PubMed that shared themes with Topic 1, focusing predominantly on the quality of life of patients with chronic diseases or cancer [25] and end-of-life care [26]. Regarding Topic 2, 194 articles were retrieved on topics such as medical liability and related topics [27], medical malpractice under criminal law [28], and doctor's liability in artificial intelligence-enabled healthcare [29]. Themes similar to Topic 3 were found in 2,646 studies retrieved from PubMed in the last decade: medical malpractice [30,31], medical litigation [32], and medical malpractice [30,31]. There were 6,106 international studies similar to Topic 4, of which 1,343 involved medical students and 1,780 involved physi-

cians. There were studies on the concept of medical professionalism [33] and the relationship between medical professionalism and doctor's well-being [34]. Topic 5 focused on the outcomes of healthcare professional development education, and 36,729 related articles were retrieved. There were also studies on competency education methods for medical students [35] or education for specific competencies of residents or doctors [36,37]. Thus, the five major themes of doctor's competencies identified in this study have been similarly studied abroad.

Third, we analyzed changes in research topics over time and found that the most frequently studied topic in Korea was Topic 5 ("competency development education for medical students"), followed by Topic 3 ("medical malpractice and litigation") and Topic 1 ("life and death in medical situations"). However, there was no significant difference in the proportion of studies by topic over time. When comparing this study with international research, it is noteworthy that there were 36,729 studies related to medical personnel competency development education in PubMed during the same period, which represents a substantial volume of research compared to other topics. In the analysis of research trends by period, from 2011 to 2016, which corresponds to the first and second periods, Topic 5 ("competency development education for medical students") was the most researched. This surge in interest likely occurred due to the shift to the medical graduate school system in 2009, prompting numerous studies related to identifying the characteristics of medical graduate students [38], curriculum development and evaluation [39], and school adaptation [40]. In addition, between 2017 and 2021 (i.e., in the third and fourth periods), Topic 3 ("medical malpractice and litigation") was extensively studied. This increased focus can be attributed to the full implementation of the end-of-life decision-making system in Korea in February 2018, leading to a significant rise in discussions on this topic before and after its introduction. Of the 280 articles retrieved using the keyword "end-of-life decision-making," 218 were published in 2017 or later, covering topics such as a review of the end-of-life decision-making system [41], comparisons with overseas end-of-life decision-making laws [42], and differences in perceptions of end-of-life decision-making [43].

According to the linear regression analysis, all the topics were considered "cool," with regression coefficients displaying negative signs that were not statistically significant, as they exceeded a significance level of 0.05. Consequently, it can be inferred that research on doctors' professional competence has been on the decline over the past decade, shifting focus toward specific competency development education, such as professional performance. Despite the lack of statistically significant differences in this study's findings, the proportion of research on Topic 5 ("competency development education for medical students") has seen

a gradual decrease from period 1 to period 4. In contrast, research on Topic 4 (“medical professionalism”) has seen an increase. This trend suggests a growing emphasis on professionalism within the common competencies of doctors. This shift aligns with the crisis in traditional medical professionalism and the societal call for a new form of professionalism that moves away from exclusive elitism [44]. The concept of medical professionalism [45], the emphasis on its importance [46], and the growing number of discussions on professionalism education methods [47] can be considered a response to the needs of the times.

As shown above, studies related to physicians’ professional competencies have been conducted on various topics, with a particular focus on medical activities as defined by the Medical Act and the development of medical personnel’s competencies. This emphasis is largely in response to current issues such as the creation of medical specialty graduate schools and the implementation of the End-of-Life Decision Act. These developments indicate a shift in research topics concerning physicians’ competencies to better align with societal changes. Thus, there is a need for ongoing refinement of competencies, taking into account societal needs and contexts. Over the past decade, research has primarily concentrated on the foundational concepts of physicians’ competencies and educational methodologies. In the future, it will be necessary for research to evaluate the effectiveness of a systematic approach to developing and educating physicians on “entrustable professional activities” that incorporate these competencies.

The limitations of this study are as follows: The analysis of research trends was segmented into four periods, with first to thirds periods spanning 3 years each, whereas fourth periods encompasses only the 2 years of 2020 and 2021. This discrepancy complicates statistical comparisons with the other periods. Furthermore, although it was anticipated that a significant number of studies would address the educational shifts prompted by coronavirus disease 2019 (COVID-19), which instigated innovative changes in medical education, only published studies were included in the fourth periods. Consequently, this does not represent the full scope of research on physician competencies related to COVID-19. Future research should focus on analyzing the ongoing trends, particularly during this critical period of transformation in medical education.

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## Conflict of interest

Youngjon Kim is an Editorial Board member of KMER, but was not involved in the peer reviewer selection, evaluation, or decision process of this article. Except for that, no other potential conflict of interest relevant to this article was reported.

## Authors' contribution

Youngjon Kim designed the study and analyzed the data and results; Jea Woog Lee analyzed the data and summarized the results; So Jung Yune designed the study and summarized the results.

## References

1. Lee SW, Kim WS, Park SB, Park JH, Park CS, Lee SY, et al. Development of general competencies and EPA based on roles of doctors in South Korea. Seoul: Korean Medical Association, Research Institute for Healthcare Policy; 2018.
2. Harden RM, Crosby JR, Davis MH, Friedman M. AMEE guide no. 14: outcome-based education: part 5-from competency to meta-competency: a model for the specification of learning outcomes. *Med Teach*. 1999;21(6):546-52. <https://doi.org/10.1080/01421599978951>
3. Carraccio C, Wolfsthal SD, Englander R, Ferentz K, Martin C. Shifting paradigms: from Flexner to competencies. *Acad Med*. 2002;77(5):361-7. <https://doi.org/10.1097/00001888-200205000-00003>
4. Leung WC. Competency based medical training: review. *BMJ*. 2002;325(7366):693-6. <https://doi.org/10.1136/bmj.325.7366.693>
5. Hodges BD, Lingard L. The question of competence: reconsidering medical education in the twenty-first century. Ithaca (NY): Cornell University Press; 2012. <https://doi.org/10.7591/9780801465802>
6. Frank JR, Danoff D. The CanMEDS initiative: implementing an outcomes-based framework of physician competencies. *Med Teach*. 2007;29(7):642-7. <https://doi.org/10.1080/01421590701746983>
7. Swing SR. The ACGME outcome project: retrospective and prospective. *Med Teach*. 2007;29(7):648-54. <https://doi.org/10.1080/01421590701392903>
8. General Medical Council. Tomorrow’s doctors: recommendations on undergraduate medical education. London: General Medical Council; 1993.
9. Han JJ. Korean doctor’s role. Seoul: Korean Council on Medical Education; 2022.

10. Lee SW. A study on the development of general competencies and entrustable professional activities (EPA) based on Korean doctor's role. *Health Policy Forum*. 2018;16(4):80-5.
11. Koh GC, Khoo HE, Wong ML, Koh D. The effects of problem-based learning during medical school on physician competency: a systematic review. *CMAJ*. 2008;178(1):34-41. <https://doi.org/10.1503/cmaj.070565>
12. Frank JR, Mungroo R, Ahmad Y, Wang M, De Rossi S, Horsley T. Toward a definition of competency-based education in medicine: a systematic review of published definitions. *Med Teach*. 2010;32(8):631-7. <https://doi.org/10.3109/0142159X.2010.500898>
13. Srinivasan M, Li ST, Meyers FJ, Pratt DD, Collins JB, Braddock C, et al. "Teaching as a competency": competencies for medical educators. *Acad Med*. 2011;86(10):1211-20. <https://doi.org/10.1097/ACM.0b013e31822c5b9a>
14. McDermott O, Crellin N, Ridder HM, Orrell M. Music therapy in dementia: a narrative synthesis systematic review. *Int J Geriatr Psychiatry*. 2013;28(8):781-94. <https://doi.org/10.1002/gps.3895>
15. Lee Y, Kang J. Related factors of turnover intention among Korean hospital nurses: a systematic review and meta-analysis. *Korean J Adult Nurs*. 2018;30(1):1-17. <https://doi.org/10.7475/kjan.2018.30.1.1>
16. Kim YH, Kim YJ. *Social network analysis*. 4th ed. Seoul: Parkyoungsa; 2016.
17. Saheb T, Saheb M. Analyzing and visualizing knowledge structures of health informatics from 1974 to 2018: a bibliometric and social network analysis. *Health Inform Res*. 2019;25(2):61-72. <https://doi.org/10.4258/hir.2019.25.2.61>
18. Blei DM. Probabilistic topic models. *Commun ACM*. 2012;55(4):77-84. <https://doi.org/10.1145/2133806.2133826>
19. Jelodari H, Wang Y, Yuan C, Feng X, Jiang X, Li Y, et al. Latent Dirichlet allocation (LDA) and topic modeling: models, applications, a survey. *Multimed Tools Appl*. 2019;78:15169-211. <https://doi.org/10.1007/s11042-018-6894-4>
20. Ham MI, Lee JW. Research Institutes Network Analysis on the established research equipment: Ministry of Knowledge Economy R&D business project. *J Korea Contents Assoc*. 2013;13(3):307-17. <https://doi.org/10.5392/jkca.2013.13.03.307>
21. Son BE, Jeon DI. Research trends analysis in quality monitoring of the general education using text network analysis. *Korean J Gen Educ*. 2020;14(5):97-108. <https://doi.org/10.46392/kjge.2020.14.5.97>
22. Rousseeuw PJ. Silhouettes: a graphical aid to the interpretation and validation of cluster analysis. *J Comput Appl Math*. 1987;20:53-65. [https://doi.org/10.1016/0377-0427\(87\)90125-7](https://doi.org/10.1016/0377-0427(87)90125-7)
23. Pieters J, Dolmans DH, van den Beuken-van Everdingen MH, War-menhoven FC, Westen JH, Verstegen DM. A national, palliative care competency framework for undergraduate medical curricula. *Int J Environ Res Public Health*. 2020;17(7):2396. <https://doi.org/10.3390/ijerph17072396>
24. Siewiera J, Trnka J, Kubler A. The issue of legal protection of the intensive care unit physician within the context of patient consent to treatment: part I: conscious patient, refusing treatment. *Anaesthesiol Intensive Ther*. 2014;46(1):50-4. <https://doi.org/10.5603/AIT.2014.0011>
25. Gotze H, Brahler E, Gansera L, Schnabel A, Gottschalk-Fleischer A, Kohler N. Anxiety, depression and quality of life in family caregivers of palliative cancer patients during home care and after the patient's death. *Eur J Cancer Care (Engl)*. 2018;27(2):e12606. <https://doi.org/10.1111/ecc.12606>
26. Aubry R. End-of-life, euthanasia, and assisted suicide: an update on the situation in France. *Rev Neurol (Paris)*. 2016;172(12):719-24. <https://doi.org/10.1016/j.neurol.2016.09.007>
27. Treglia M, Pallocci M, Passalacqua P, Giammatteo J, De Luca L, Mauriello S, et al. Medical liability: review of a whole year of judgments of the Civil Court of Rome. *Int J Environ Res Public Health*. 2021;18(11):6019. <https://doi.org/10.3390/ijerph18116019>
28. Gutorova N, Zhytnyi O, Kahanovska T. Medical negligence subject to criminal law. *Wiad Lek*. 2019;72(11 cz 1):2161-6. <https://doi.org/10.36740/wlek201911118>
29. Tobia K, Nielsen A, Stremitzer A. When does physician use of ai increase liability? *J Nucl Med*. 2021;62(1):17-21. <https://doi.org/10.2967/jnumed.120.256032>
30. Berlin L. Medical errors, malpractice, and defensive medicine: an ill-fated triad. *Diagnosis (Berl)*. 2017;4(3):133-9. <https://doi.org/10.1515/dx-2017-0007>
31. Tumelty ME. Medical negligence litigation and apologies: an empirical examination. *Eur J Health Law*. 2020;27(4):386-403. <https://doi.org/10.1163/15718093-BJA10021>
32. Durand MA, Moulton B, Cockle E, Mann M, Elwyn G. Can shared decision-making reduce medical malpractice litigation?: a systematic review. *BMC Health Serv Res*. 2015;15:167. <https://doi.org/10.1186/s12913-015-0823-2>
33. Fitzgerald A. Professional identity: a concept analysis. *Nurs Forum*. 2020;55(3):447-72. <https://doi.org/10.1111/nuf.12450>
34. Shrivastava SR, Shrivastava PS. Medical professionals: need and role of professionalism. *Indian J Health Sci Biomed Res KLEU*. 2020;13(2):167-8. [https://doi.org/10.4103/kleuhsjkleuhsj\\_283\\_19](https://doi.org/10.4103/kleuhsjkleuhsj_283_19)
35. Westmoreland KD, Banda FM, Steenhoff AP, Lowenthal ED, Isaksson E, Fassl BA. A standardized low-cost peer role-playing training in-

- tervention improves medical student competency in communicating bad news to patients in Botswana. *Palliat Support Care*. 2019; 17(1):60-5. <https://doi.org/10.1017/S1478951518000627>
36. Wentzell DD, Chung H, Hanson C, Gooi P. Competency-based medical education in ophthalmology residency training: a review. *Can J Ophthalmol*. 2020;55(1):12-9. <https://doi.org/10.1016/j.jcjo.2019.07.004>
37. Mainous AG 3rd, Xie Z, Yadav S, Williams M, Blue AV, Hong YR. Physician cultural competency training and impact on behavior: evidence from the 2016 National Ambulatory Medical Care Survey. *Fam Med*. 2020;52(8):562-9. <https://doi.org/10.22454/FamMed.2020.163135>
38. Chun KH. Relationship between academic burnout of medical and graduate students and related variables. *Korean Med Educ Rev*. 2014;16(2):77-87. <https://doi.org/10.17496/kmer.2014.16.2.077>
39. Yoo HH, Park KH. Career guidance program design for the graduate medical school students. *J Korea Contents Assoc*. 2014;14(12):873-80. <https://doi.org/10.5392/jkca.2014.14.12.873>
40. Yune SJ, Park KH. Analysis of reflective essays on the learning community experiences of medical students. *Korean Med Educ Rev*. 2016;18(3):167-73. <https://doi.org/10.17496/kmer.2016.18.3.167>
41. Choi JY, Jang SG, Kim CA, Lee I. Institutional ethics committees for decisions on life-sustaining treatment in Korea: their current state and experiences with their operation. *Korean J Med Ethics*. 2019;22(3):209-33. <https://doi.org/10.35301/ksme.2019.22.3.209>
42. Choi EK, Hong J, Kim MS, Keam B, Kim M, Heo DS, et al. The decision-making process regarding life-sustaining treatment in four countries: Taiwan, Japan, the US, and the UK. *Korean J Med Ethics*. 2017;20(2):131-51. <https://doi.org/10.35301/ksme.2017.20.2.131>
43. Hwang H, Yang SJ. A comparative study on the perceptions of elderly patients and their caregivers toward life-sustaining treatment. *Korean J Med Ethics*. 2016;19(4):484-503. <https://doi.org/10.35301/ksme.2016.19.4.484>
44. Smith R. Medical professionalism: out with the old and in with the new. *J R Soc Med*. 2006;99(2):48-50. <https://doi.org/10.1177/014107680609900202>
45. Han ER, Chung EK. Understanding medical professionalism. *Korean Med Educ Rev*. 2020;22(2):143. <https://doi.org/10.17496/kmer.2020.22.2.143>
46. Ahn DS. Medical professionalism, why now? *Healthc Policy Forum*. 2018;16(2):5-8.
47. Yoo HH, Kim YJ. The implementation and evaluation of learning experience-based professionalism program in medical school. *J Korea Contents Assoc*. 2018;18(1):164-72. <https://doi.org/10.5392/jkca.2018.18.01.164>