

Survey of Bachelor of Pharmacy Students Thesis Trends Before, During, and After the Covid-19 Pandemic

Muhammad Royyan Alfatah¹, Anna Wahyuni Widayanti², Agung Endro Nugroho^{3*} and Arief Rahman Hakim³

1. Bachelor's Program in Pharmacy, Faculty of Pharmacy, Universitas Gadjah Mada, Sekip Utara, 55281, Yogyakarta, Indonesia
2. Department of Pharmaceutics, Faculty of Pharmacy, Universitas Gadjah Mada, Sekip Utara, 55281, Yogyakarta, Indonesia
3. Department of Pharmacology & Clinical Pharmacy, Faculty of Pharmacy, Universitas Gadjah Mada, Sekip Utara, 55281, Yogyakarta, Indonesia

Article Info

Submitted: 15-12-2023

Revised: 04-07-2024

Accepted: 07-08-2024

*Corresponding author
Agung Endro Nugroho

Email:
agungendronugroho@gmail.com

ABSTRACT

The coronavirus disease 2019 (COVID-19) pandemic spread to Indonesia in March 2020 but subsided by mid-2022. The pandemic had a major impact on the health of people all around the world and affected other aspects of life, especially education, where it affected academic activities in higher education. This study aims to describe the research patterns of a bachelor's pharmacy student's thesis before, during, and after the COVID-19 pandemic. We also investigated the reasons for students choosing thesis research topics. The study was designed to be conducted observationally with a questionnaire to collect data. The respondents were made up of pharmacy undergraduate students at Universitas Gadjah Mada who were completing or had completed their thesis during the period before, during, or after the pandemic. The data obtained were analyzed descriptively according to the same variables, such as trends in thesis research topics, students' reasons for determining topics, and the number of journal publications resulting from thesis research. The total number of respondents who completed the questionnaire was 258, with 53, 100, and 95 students conducting the research before, during, and after the pandemic, respectively. Before the pandemic, most of respondents conducted research on the topics of pharmaceutical technology (22.73%). In terms of research methods, most of them conducted laboratory-based research (76.06%). During the pandemic, the research topic was dominated by pharmacotherapy and clinical pharmacy (34.88%), and the most common type of final project study was a literature review (47.57%). After the pandemic subsided in mid-2022, the topic of pharmacy management and community pharmacy (41.94%) was the most dominant. In this study, we observed that scientific interest and supervisor competence were the two main reasons for students to determine the topic of research topics. Based on this study, we conclude that the COVID-19 pandemic influenced the trends of bachelor's pharmacy students' theses.

Keywords: bachelor pharmacy student, thesis, trends, COVID-19.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic was first reported in Wuhan, Hubei Province, China, and spread rapidly to many countries across all continents. The disease infected approximately 36.5 million people and killed over one million people globally. The World Health Organization (WHO) proclaimed the

COVID-19 outbreak as a pandemic on March 11, 2020 (Sharma *et al.*, 2021; Zhu *et al.*, 2019). The pandemic emerged in Indonesia in March 2020. It had a huge and widespread impact not only on the health sector, but also on various other aspects of life such as the economy, society, and education in Indonesia. The widespread impact of the pandemic that began to impact the education

sector has resulted in many educational institutions not conducting face-to-face learning activities and replacing them with online contact (McKibbin & Fernando, 2020). The Indonesian government released a policy to implement “working from home” and “teaching and learning from home” for physical and social distancing. Since then, an online learning system has been implemented in most teaching and learning activities. However, as a challenge in the era of the Fourth Industrial Revolution (Aoun, 2017; Cazarez, 2020), the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia has already encouraged universities to introduce online and hybrid or blended learning two years earlier, in 2018.

In college education, online learning was conducted using synchronous (Webex, Zoom, Google Meet, Skype, etc.) and asynchronous (learning management system) methods. The impact of the pandemic has led the Ministry of Education and Culture of the Republic of Indonesia to issue a policy to allow thesis implementation without carrying out field research that would otherwise require direct contact and replace it with literature studies (Gusholianda *et al.*, 2022). This policy change has seen some pharmacy students collect research data using online searches, such as consulting online databases, websites, the internet, and other sources. Students are encouraged to conduct online research, especially literature studies (narrative review, evidence review, systematic review, meta-analysis), or collect data through online surveys.

Research is a scientific, systematic approach that aims to gain a deeper understanding of or solution to a particular problem or more generally develop science and knowledge. Academic research is a part of the educational process in undergraduate pharmacy programs. Based on Regulation of the Minister of Education and Culture Number 30 of 2020 on National Standards for Higher Education article 14 (Kemendikbud, 2020), a bachelor's thesis is a scientific work in a certain field of science written based on the results of research, fieldwork practice, internship, literature study, or other tasks determined by the faculty (with bachelor's students under supervision by lecturers) (Rahyono, 2010). In pharmacy education, research can be conducted by students referring to pharmaceutical scientific competencies based on science groups which are the pillars of pharmacy education. These pillars include basic natural sciences, basic biomedical

sciences, social/behavioural/administrative sciences, clinical sciences, and pharmacy practice and pharmacy-provided care (HPEQ Project, 2013). At most universities in Indonesia, scientific development and research are conducted by laboratories, which are coordinated within a department. The laboratory functions to support education, knowledge development, research, and community service at the faculty level. Therefore, in general, pharmaceutical sciences are mainly developed through laboratories at the pharmacy faculty (Universitas Gadjah Mada, 2015).

Students conducting their bachelor's thesis research have various choices of types of research that can be carried out. Some examples of bachelor theses that are generally conducted are laboratory research, observational research with questionnaires or surveys, qualitative research with interviews, literature review research (narrative review, systematic review), and secondary data analysis research, etc. (Sugiyono, 2015). In their research, students can choose one or more options in terms of scientific fields and types of research. In this study, we investigate the research patterns of bachelor's pharmacy students' theses before, during, and after the pandemic. We also observed the reasons for students choosing thesis research topics and the percentage of theses subsequently published in journals or proceedings.

MATERIALS AND METHODS

Study Design

This study is an observational study with a quantitative approach to describe the research patterns of bachelor's pharmacy student theses before, during, and after the pandemic; and explore the factors that influence students in determining topics. In addition, we also observed the percentage of theses subsequently published in journals or proceedings. The research instrument used to collect data was a questionnaire distributed to the students. Respondents who completed the questionnaire were divided into three categories: before, during, and after the pandemic period. The division is based on the period of research and preparing a thesis, predominantly categorized as taking place in one of these periods. The period before the pandemic was based on a bachelor's thesis written before mid-March 2020 when the Indonesian government declared the coronavirus pandemic a national disaster. The period after the pandemic was based on the fact that the pandemic had subsided and universities have allowed academic activities on campus, including

education, teaching, and research, in the odd semester of 2022.

Study Subjects

The study centered on bachelor's pharmacy students in the Faculty of Pharmacy Gadjah Mada University (UGM) (batch of 2014–2019), and the data were collected from July to November 2023. Inclusion criteria in the study were bachelor's pharmacy students from UGM, who were completing or had completed their thesis during the period before, during, and after the pandemic. The exclusion criteria were dropped-out students and incomplete/unfinished questionnaires.

Research Ethics

The protocol was approved by the Medical and Health Research Ethics Committee UGM Indonesia. The protocol meets the ethical principles outlined in the International and National Guidelines on ethical standards and procedures for research with human beings (Ref. No. KE/FK/0972/EC/2023). Before the respondents completed the questionnaire, they received detailed information about the study. After they agreed to participate in the study, they were asked to complete the questionnaire. After completing the questionnaire, the participants were thanked for their participation.

Data Collection and Analysis

The questionnaire was distributed to UGM bachelor's pharmacy students (batch of 2014–2019) through class groups with an average of 200 members and approximately 170 personal messages to respondents via WhatsApp. This research questionnaire was divided into two parts. The first part consisted of questions related to the respondent's general profile and the second part consisted of questions related to the respondent's thesis profile. The first part of the questionnaire contained questions related to the respondent's general profile such as name, gender, age, academic year batch, thesis status, thesis implementation time, and thesis implementation stages, as well as the supervisor's profile.

The second part of the questionnaire contained questions related to the student's thesis profile. The questions in this section included the scientific field, thesis title/topic, thesis research type, research costs, funding sources, the possibility of topic change, the possibility of supervisor change, and the number of published

bachelor's theses. The data obtained were analyzed using descriptive statistics to describe the data presented in the form of tables and graphs.

RESULTS AND DISCUSSION

Subject Characteristics

In total, 258 respondents were included in the research inclusion criteria. The respondents were divided into three categories/groups: working on their thesis before, during, and after the pandemic, with a total of 53, 100, and 95 students, respectively. Among the respondents, the dominant age range was 22–23 years (51.54%), and the academic student batch was 2019 (32.69%). The proportion of male and female respondents was 29.62% and 70.38%, respectively. Based on the number of supervisors in place before and after the pandemic, most respondents were supervised by two supervisors, supervising 60.38% and 53.61%, respectively. During the pandemic, student research was only guided by one supervisor (70.91%).

Research Topic Pattern

In this study, we observed the bachelor's research topic pattern based on a scientific discipline/field that refers to laboratories in the faculty. Most universities in Indonesia conduct scientific development and research through laboratories managed within a department. The laboratory functions to support education, knowledge development, research, and community service at the faculty level. In the Faculty of Pharmacy, UGM, there are ten scientific discipline/field categories in research, namely, pharmacognosy and phytochemistry, microbiology and cell biology, pharmaceutical technology, biopharmaceuticals and physical pharmacy, pharmacy management and community pharmacy, medicinal chemistry, analytical chemistry, macromolecular engineering, pharmacology and toxicology, and clinical pharmacy and pharmacotherapy.

The research of a bachelor's thesis can involve one scientific discipline (monodisciplinary) or more than one scientific field (multidisciplinary). The latter can be intradisciplinary or interdisciplinary. Intradisciplinary research involves more than one scientific field but is still within one scientific group or department. Meanwhile, interdisciplinary research involves more than one scientific field from other scientific groups or departments. In this study, a bachelor's thesis research is mostly monodisciplinary.

Table I. The pattern of monodisciplinary bachelor's thesis research before, during, and after the COVID-19 pandemic

Scientific Group	Scientific Field	Period of COVID-19 pandemic					
		Before	% (n=44)	During	% (n=86)	After	% (n=61)
Pharmaceutical Biology	Pharmacognosy and Phytochemistry	6	13.64	3	3.49	4	6.56
	Microbiology and Cell Biology	3	6.82	2	2.33	0	0.00
	Pharmaceutical Technology	10	22.73	11	12.79	7	11.48
Pharmaceutics	Biopharmaceuticals and Physical Pharmacy	0	0.00	3	3.49	0	0.00
	Pharmacy Management and Community Pharmacy	7	15.91	28	32.56	26	42.62
	Medicinal Chemistry	2	4.55	2	2.33	2	3.28
Pharmaceutical Chemistry	Analytical Chemistry	2	4.55	1	1.16	2	3.28
	Macromolecular Engineering *	0	0.00	4	4.65	2	3.28
Pharmacology and Clinical Pharmacy	Pharmacology and Toxicology	7	15.91	2	2.33	1	1.64
	Clinical Pharmacy and Pharmacotherapy	7	15.91	30	34.88	17	27.87
	Total	44	100	86	100	61	100

*The Macromolecular Engineering Laboratory was established in 2019 following the Decree of the Rector of Universitas Gadjah Mada Number 626/UN1.P/KPT/HUKOR/2019

Based on our research data, before the COVID-19 pandemic, the percentages of research in one (monodisciplinary), two, and three (intradisciplinary and interdisciplinary) scientific fields were 83.01%, 15.09%, and 1.89%, respectively. During the pandemic, the percentages were 78.18%, 20.0%, and 1.82%, whereas after the pandemic, they were 63.92%, 28.87%, and 7.22%, respectively.

This study found that before the pandemic, the monodisciplinary thesis research topics most frequently undertaken by students were pharmaceutical technology (22.73%), pharmacy management and community pharmacy (15.91%), pharmacology and toxicology (15.91%), and clinical pharmacy and pharmacotherapy (15.91%) (Table I). During the pandemic, there was a marked change in the percentage of thesis research topics. The dominant scientific fields were clinical pharmacy and pharmacotherapy (34.88%), pharmacy management and community pharmacy (32.56%), and pharmaceutical technology. After the pandemic, the dominant scientific fields of bachelor's theses were pharmacy management and community pharmacy (42.62%), clinical pharmacy and pharmacotherapy

(27.87%), and pharmaceutical technology (11.48%). Some scientific disciplines underwent an increase in percentage take-up after the pandemic compared with those before the pandemic. These include pharmacy management and community pharmacy, and clinical pharmacy and pharmacotherapy.

The pattern of multidisciplinary (two scientific fields) bachelor's thesis research before, during, and after the pandemic (Table II), there are some combinations of two scientific fields in both the same and different scientific groups/departments. The percentage of multidisciplinary (two scientific fields) research increased before, during, and after the pandemic by 15.09%, 20.0%, and 28.8%, respectively. Before the pandemic, the two scientific fields most often combined were pharmacognosy and phytochemistry with pharmacology and toxicology (25.0%), microbiology and cell biology with pharmaceutical technology (25.0%), and pharmaceutical technology with biopharmaceuticals and physical pharmacy (25%). During the pandemic, a combination of pharmaceutical technology with biopharmaceuticals and physical pharmacy was the most frequently chosen by students (18.18%).

Table II. The pattern of multidisciplinary (two scientific fields) bachelor's thesis research before, during, and after the COVID-19 pandemic

Scientific Field 1	Scientific Field 2	Periods of COVID-19 Pandemic					
		Before	% (n=8)	During	% (n=22)	After	% (n=27)
Pharmacognosy and Phytochemistry	Microbiology and Cell Biology	0	0.00	0	0.00	5	18.52
Pharmacognosy and Phytochemistry	Pharmaceutical Technology	0	0.00	1	4.55	3	11.11
Pharmacognosy and Phytochemistry	Biopharmaceuticals and Physical Pharmacy	0	0.00	1	4.55	0	0.00
Pharmacognosy and Phytochemistry	Medicinal Chemistry	0	0.00	2	9.09	0	0.00
Pharmacognosy and Phytochemistry	Analytical Chemistry	0	0.00	1	4.55	2	7.41
Pharmacognosy and Phytochemistry	Macromolecular Engineering	0	0.00	2	9.09	4	14.81
Pharmacognosy and Phytochemistry	Pharmacology and Toxicology	2	25.00	1	4.55	0	0.00
Microbiology and Cell Biology	Pharmaceutical Technology	2	25.00	2	9.09	4	14.81
Microbiology and Cell Biology	Medicinal Chemistry	1	12.50	0	0.00	0	0.00
Microbiology and Cell Biology	Analytical Chemistry	0	0.00	0	0.00	1	3.70
Pharmaceutical Technology	Biopharmaceuticals and Physical Pharmacy	2	25.00	4	18.18	1	3.70
Pharmaceutical Technology	Medicinal Chemistry	1	12.50	2	9.09	1	3.70
Pharmaceutical Technology	Pharmacology and Toxicology	0	0.00	1	4.55	1	3.70
Pharmacy Management and Community Pharmacy	Clinical Pharmacy and Pharmacotherapy	0	0.00	2	9.09	3	11.11
Medicinal Chemistry	Macromolecular Engineering*	0	0.00	0	0.00	1	3.70
Medicinal Chemistry	Analytical Chemistry	0	0.00	0	0.00	1	3.70
Medicinal Chemistry	Pharmacology and Toxicology	0	0.00	1	4.55	0	0.00
Analytical Chemistry	Pharmacology and Toxicology	0	0.00	1	4.55	0	0.00
Pharmacology and Toxicology	Clinical Pharmacy and Pharmacotherapy	0	0.00	1	4.55	0	0.00
Total		8	100	22	100	27	100

*The Macromolecular Engineering Laboratory was established in 2019 following the Decree of the Rector of Universitas Gadjah Mada Number 626/UN1.P/KPT/HUKOR/2019

After the pandemic subsided, an intradisciplinary combination of pharmacognosy and phytochemistry with microbiology and cell biology was the most popular choice among final-year students (18.52%). Interdisciplinary combinations of pharmacognosy and phytochemistry with macromolecular engineering (14.81%) and microbiology and cell biology with pharmaceutical technology (14.81%) were the second most common choices. In the study, we also observed three scientific fields of bachelor's thesis research

before, during, and after the pandemic, although the number was relatively small. The percentages of multidisciplinary (three scientific fields) research before, during, and after the pandemic were 1.89%, 1.82%, and 7.22%, respectively. After the pandemic, we identified seven cases of a multidisciplinary research combination. Two of them were related to a combination of pharmacognosy and phytochemistry, pharmaceutical technology with analytical chemistry.

Table III. Types of bachelor's thesis research with a single scientific approach before, during and after the COVID-19 pandemic

Types of bachelor's student thesis research	Periods of the COVID-19 pandemic					
	Before	% (n=46)	During	% (n=103)	After	% (n=88)
Laboratory-based research	35	76.09	9	8.74	43	48.86
Observational research with questionnaires or surveys	5	10.87	18	17.48	19	22.73
Qualitative research with interviews	1	2.17	5	4.85	5	5.68
Literature review	0	0.00	49	47.57	6	5.68
Secondary data analysis research	5	10.87	17	16.50	14	15.91
Miscellaneous	0	0.00	5	4.85	1	1.14
Total	46	103	103	100	88	100

Types of Bachelor's Student Thesis Research

Students carrying out their thesis research can use several approaches. These include laboratory-based research, observational research with questionnaires or surveys, qualitative research with interviews, literature review, secondary data analysis, and other studies. In general, students employ one approach to conducting their thesis research. However, in a few cases, they conducted research using at least two scientific approaches. Among all respondents, 91.92% of the thesis research employed a single scientific approach, and only 8.09% used two approaches. As a description, the percentages of thesis research with a single scientific approach before, during, and after the pandemic were 88.79%, 93.64%, and 92.78%, respectively.

Before the pandemic, bachelor's theses were conducted predominantly using laboratory-based research (79.06%), but the pandemic influenced the types of research approaches (Table III). Laboratory-based research was only conducted by 8.97% of students. The predominant research approach during the pandemic was the literature review (47.57%). Two other options under this condition were observational research with questionnaires or surveys (17.48%) and secondary data analysis research (16.50%). However, after the pandemic subsided, laboratory-based research was the most preferred method for students to conduct a study (48.86%). Observational research with questionnaires or surveys (22.73%) and secondary data analysis research (15.91%) are still the second most popular methods for students.

In this study, we found seven research cases that employed two research approaches in each

period (data not shown). For instance, in four cases before the pandemic, the studies employed laboratory-based research with a literature review. This means that a literature review can be used to support other scientific approaches. There is no case in which it was used as a single approach (Table III). In another example, in three cases after the pandemic, the research implemented two approaches simultaneously: qualitative research with interviews and secondary data analysis.

Research Funding and Costs

Funding and costs are two factors that students should pay attention to when preparing and conducting their research. Before the pandemic, bachelor's thesis research was supported by a supervisor's research project/grant (69.81%) or an independent/student personal fund (30.19%). However, during the pandemic, the research was undertaken by students using personal funds (63.64%), a supervisor's research grant (30.91%), or a combination of the two (4.54%). The financial combination means that only some parts are supported by the supervisor's research grant. In the period after the pandemic, student research was supported financially by personal funds (46.39%), a supervisor's research grant (41.24%), a combination of the two (10.31%), and scholarships (2.06%).

We observed bachelor's student research costs before, during, and after the pandemic. Before the pandemic, student research cost less than 1 million rupiah and ranged from 1 to 5 million rupiah which were 20.75% and 32.08%, respectively. In total, 16.98% of the total number of research projects had a cost of more than 25 million rupiah.

Table IV. Reasons for bachelor's students choosing thesis research topics before, during, and after the COVID-19 pandemic

Reasons to determine the topic	Periods of the COVID-19 pandemic					
	Before % (n=113)		During % (n=299)		After % (n=218)	
Scientific interest	29	25.66	57	19.06	51	23.39
Easy and simple method of implementation	9	7.96	58	19.40	31	14.22
Low cost	9	7.96	42	14.05	20	9.17
Fast implementation	7	6.19	39	13.04	19	8.72
Supervisor competency	28	24.78	57	19.06	49	22.48
Assumption of getting a high score	0	0.00	3	1.00	7	3.21
Research group/team	24	21.24	32	10.70	31	14.22
Friends' suggestions	6	5.31	8	2.68	9	4.13
Miscellaneous	1	0.88	3	1.00	1	0.46
Total	113	10	299	100	218	100

During the pandemic, student research costs of less than 1 million rupiah were the most frequent (73.64%). Student research costs ranging from 1 to 5 million and more than 25 million rupiah were 15.45% and 0.91%, respectively. After the pandemic subsided, the most dominant research costs were still around less than 1 million rupiah (46.39%). The percentage of student research expenses ranging from 1 to 5 million was 32.99%.

Reasons for Students Choosing a Thesis Research Topic

In general, in Indonesia, bachelor's students do their thesis research in the last semester of the year, and they have to propose a topic and title in the form of a thesis research proposal, as well as supervisors. In the study, we also observed students' reasons for choosing the scientific field topic of their final project. These students' reasons included scientific interest; easy, fast, and simple method; low cost; supervisor competency; assumption of getting a high score; research group/team; and friends suggestions. In this case, respondents can choose more than one option/reason. In the study, we collected 630 answers from 258 respondents (Table IV).

Based on the results, before the pandemic, the dominant reasons for bachelor's students choosing topics were scientific interest (25.66%), supervisor competency (24.78%), and working in a particular research group/research team (21.24%). However, the pandemic influenced the students' decisions on the research thesis topics. During the pandemic, easy and simple methods of

implementation became the priority for students in choosing the research topic (19.40%). Besides, the students still gave two reasons for their main considerations: scientific interest (19.06%) and supervisor competency (19.06%). After the pandemic subsided, the two last reasons became the highest priorities for the students in determining the research topic (23.39% and 22.48%, respectively, Table IV).

Reasons for Students Choosing a Thesis Supervisor

In preparing a bachelor's thesis, including proposals, research work, and publications, students are guided by a supervisor. They can be a lecturer, researcher, expert, or practitioner in related scientific fields. The number of supervisors depends on the need for scientific competency related to the research to be conducted. Table V lists the reasons used by students to determine their choice of supervisor. These reasons include ease of communication, ease of interaction, supervisor expertise or competence, following the scientific field, ease of obtaining scores, recommendations from friends or seniors, and research grant availability. In the study, two main reasons for bachelor's students choosing a supervisor were supervisor expertise or competence and appropriateness to the scientific field in the three periods (before, during, and after the pandemic). It is also interesting that ease of communication and ease of interaction are the next highest-scoring reasons for the student's choice (Table V).

Table V. Reasons for students choosing a thesis supervisor in the periods before, during and after the COVID-19 pandemic

Reasons for students choosing a thesis supervisor	Periods of the COVID-19 pandemic					
	Before	% (n=167)	During	% (n=425)	After	% (n=335)
Ease of communication	23	13.77	74	17.41	65	18.81
Ease of interaction	19	11.38	66	15.53	60	17.31
Supervisor expertise or competence	36	21.56	90	21.18	68	19.70
Following the scientific field	34	20.36	92	21.65	77	22.39
Ease of getting scores	9	5.39	31	7.29	17	4.78
Recommendations from friends or seniors	13	7.78	37	8.71	23	6.87
Research grant availability	33	19.76	33	7.76	33	9.25
Miscellaneous	0	0.00	2	0.47	3	0.90
Total	167	100	425	100	335	100

Table VI. Type of bachelor's thesis research publication in the periods before, during, and after the COVID-19 pandemic

Type of bachelor's thesis research publication	Periods of the COVID-19 Pandemic					
	Before	% (n=53)	During	% (n=110)	After	% (n=97)
National Journal	7	13.21	11	10.00	12	12.37
International Journal	5	9.43	8	7.27	12	12.37
Presentation at an National Conference/Seminar	1	1.89	2	1.82	2	2.06
Presentation at an International Conference/Seminar	1	1.89	7	6.36	1	1.03
Miscellaneous	0	0.00	0	0.00	1	1.03
Total	14	26.41	28	25.46	28	28.87

Bachelor's Thesis Research Publication

In the undergraduate program, in general, after students complete their bachelor's thesis, they are not obliged to publish the research. According to the National Higher Education Standards (Kemendikbud, 2020), students are only required to prepare a scientific description of the results of research or scientific studies in the form of a bachelor's thesis or final assignment report and upload it onto the university website. However, it will be of added value if they can produce publications in the form of presentations at national or international seminars or conferences, or publications in reputable national or international journals.

As many as 26.41% of the respondents published their thesis research. However, after the pandemic, the percentage decreased slightly to 25.46% but then rose to 28.87% after the pandemic

subsided. respectively. Among these publications, we also investigated the type of bachelor's thesis research published. Table VI lists the percentage and type of bachelor's thesis research publications. The types of publications were dominated by national and international publications in all periods (see Table VI). In this case, the number of international publications after the pandemic period tended to increase.

The COVID-19 pandemic has had a significant impact on many aspects of human life, including learning. The Indonesian government adopted a policy for physical and social distancing in mid-March 2020, allowing people to work from home and teach and learn from home. Since then, most teaching and learning activities have used an online learning system. However, previously in 2018, the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia had

encouraged universities to incorporate online and hybrid or blended learning as a challenge during the Fourth Industrial Revolution. Higher education is challenged by this global disruption wave or the era of disruptive technology. Klaus Schwab, founder of the World Economic Forum, first introduced the term, which refers to a state of individuals living, working, and interacting with each other involving the digital domain and innovative technology to enable and manage their lives (Schwab, 2016). The new era transforms electronic devices and information technology into a cyber-physical system, a combination of digital, physical, and biological domains. Based on these facts, during the pandemic, we were ready to face the outbreak by implementing online learning with digital technology.

The pandemic has been able to influence academic performance since the implementation of online learning. However, controlling variables that have a direct or indirect impact on academic performance tends to improve academic performance. These variables include the learning environment, the level of student engagement, the teacher, the readiness for self-directed learning, coping strategies, spiritual and emotional maturity, positive student attitude, and practice (Adli et al., 2022; Istadi et al., 2022). The lesson from the pandemic is that universities/academics are trying to maintain online learning through hybrid learning (Wray and Kinman, 2022; Singh et al., 2021; Osaili et al., 2023). Reportedly, most students think that online learning is beneficial. With equal access to online resources, online learning seems to be a successful teaching method (Chandrasiri and Weerakoon, 2022; Zheng et al., 2021). Academic staff can combine reduced face-to-face teaching with online provision (Wray and Kinman, 2022). We can implement combination learning or hybrid learning in some academic activities such as lectures, discussions, examinations, and meetings. Moreover, academic experiences in the COVID-19 era can inspire more innovative, agile, and adaptable teaching and learning methods after the pandemic has subsided (Mohamed et al., 2021). In this study, the pandemic influenced the pattern of the bachelor's thesis research topic. In non-disciplinary research, there has been a shift in the most dominant research topics, from pharmaceutical technology (before the pandemic) to clinical pharmacy and pharmacotherapy (during the pandemic) and pharmacy management and community pharmacy (after the pandemic).

These last two scientific fields have been dominant because of the pandemic until now (the last time data were collected). In line with this, the pandemic caused laboratory-based research to experience a drastic decline, although after the pandemic subsided, it increased again. During the pandemic, the university restricted laboratory use by reducing the laboratory capacity to consider physical and social distancing. During the pandemic, literature reviews and observational research using questionnaires or surveys were considered effective approaches in physical and social distancing efforts. This is interesting because the number of publications in the form of literature reviews, especially systematic reviews, has been increasing recently. It is becoming more popular as a way of conducting research. Systematic reviews appear to be becoming more common in the published literature as they are frequently regarded as key sources of clinical data (Powell & Koelemay, 2021). These findings are also related to students' thesis research costs. The trend for research costs during the pandemic also decreased to less than 1 million rupiah. In general, this could mean that the costs of literature reviews are cheaper than those of other types of bachelor's thesis research, especially laboratory-based research. During the pandemic, students made easy and simple methods of implementation the main consideration in carrying out their research, besides also considering the main aspects of scientific interest and supervisor competency.

CONCLUSION

Based on these results, we conclude that the pandemic has had a major impact on the education sector. This impact can be observed in the pattern of bachelor's thesis research. The pattern of final project topics and scientific fields has changed. Before the pandemic, it was dominated by scientific fields that were generally conducted in the laboratory, while during the pandemic, it was directed more toward social and clinical research. The types of bachelor's student thesis research have also changed with a decrease in laboratory-based research during the pandemic, while literature review research has increased. Consequently, it can decrease the bachelor's thesis research costs during the pandemic. During the pandemic, students considered easy and simple methods of carrying out their thesis research, besides prioritizing scientific interest and supervisor competency as two main aspects.

ACKNOWLEDGMENTS

We would like to thank the Faculty of Pharmacy Universitas Gadjah Mada for providing funding for this study through the Bachelor Thesis Supporting Research Grant Scheme 2023. We also thank Prof. Nanang Munif Yasin and Dr. Purwanto for supporting the research and the manuscript preparation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- Aoun, Joseph. (2017). Robot-Proof: Higher Education in the Age of Artificial Intelligence. 10.7551/mitpress/11456.001.0001.
- Cazarez R.L.U. (2020). Joseph E. Aoun: Robot proof: higher education at the age of artificial intelligence, *Genetic Programming and Evolvable Machines*, 21, 265–26
- Chandrasiri N.R., Weerakoon B.S. (2022). Online learning during the COVID-19 pandemic: Perceptions of allied health sciences undergraduates. *Radiography (Lond)*. 28(2), 545-549.
- Gusholianda, D., Lorita, E., & Yusuarsono. (2022). Administrative Services of the Faculty of Social Sciences in University of Dehasen Bengkulu for Students During the Covid-19 Pandemic. *Jurnal ISO*, 2(1), 69-76.
- HPEQ Project. (2013). Indonesian Pharmacist Education, Health Professional Education Quality Project, Collaboration between the Association of Indonesian Pharmacy Higher Education and the Indonesian Pharmacist Association.
- Adli I., Widyahening I.S., Lazarus G., Phowira J., Baihaqi L.A., Ariffandi B., Putera A.M., Nugraha D., Gamalliel N., Findyartini A. (2022). Knowledge, attitude, and practice related to the COVID-19 pandemic among undergraduate medical students in Indonesia: A nationwide cross-sectional study. *PLoS One*. 17(1), e0262827.
- Istadi Y., Raharjo T.J., Azam M., Mulyono S.E. (2022). Academic Performance in Medical Education During the COVID-19 Pandemic: A Scoping Review. *Adv Med Educ Pract*, 13, 1423-1438.
- Kemendikbud. (2020). National Standards for Higher Education. The Regulation of the Minister of Education and Culture. Republik of Indonesia.
- McKibbin, W., and Fernando, R. (2020) The Global Macroeconomic Impacts of COVID-19: Seven Scenarios. *Asian Economic Papers*, 20(2), 1-5.
- Mohamed, M., Mak, V., Sumalatha, G., Nugroho, A.E., Hertiani, T., Zulkefeli, M., Dorjbal, E., Dashbaljir, S., Faller, E., Benosa, C. A., Zaini, S. (2021). Pharmacy education during and beyond COVID-19 in six Asia-Pacific countries: Changes, challenges, and experiences. *Pharmacy Education*, 20, 183-195.
- Osaili T.M., Ismail L.C, El Mehdi H.M., Al-Nabulsi A.A., Taybeh A.O., Saleh S.T., et al. 2023. Comparison of students' perceptions of online and hybrid learning modalities during the COVID-19 pandemic: The case of the University of Sharjah. *PLoS One*, 18(3), e0283513.
- Powell, J., Koelemay, M. (2021). Systematic Reviews of the Literature Are Not Always Either Useful or The Best Way To Add To Science. *EJVES Vascular Forum*, 54, 2-6.
- Rahyono, F. X. (2010). *Kiat menyusun skripsi dan strategi [Tips for preparing a thesis and strategies]*. Jakarta, Indonesia: Penaku.
- Schwab, K. (2016). *The Fourth Industrial Revolution*, World Economic Forum, Cologny/Geneva Switzerland.
- Universitas Gadjah Mada. (2015). *Peraturan Rektor UGM Nomor 5/P/SK/HT/2015 tentang Pengelolaan Laboratorium [UGM Rector Regulation Number 5/P/SK/HT/2015 on Laboratory Management]*. Yogyakarta, Indonesia: Universitas Gadjah Mada.
- Sharma, A., Ahmad Farouk, I., Lal, S.K. (2021). COVID-19: A Review on the Novel Coronavirus Disease Evolution, Transmission, Detection, Control and Prevention. *Viruses*, 13(2), 202.
- Singh, J., Steele, K., Singh, L. (2021). Combining the Best of Online and Face-to-Face Learning: Hybrid and Blended Learning Approach for COVID-19, Post Vaccine, & Post-Pandemic World. *Journal of Educational Technology Systems*. 50(2), 140-171.
- Sugiyono. (2015). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif dan R&D [Educational research methods: Quantitative, qualitative, and R&D approaches]*. Bandung, Indonesia: Alfabeta.

- Wray S, Kinman G. (2022). The challenges of COVID-19 for the well-being of academic staff. *Occup Med (Lond)*. 72(1), 2-3.
- Zheng, M., Bender, D., Lyon, C. (2021). Online learning during COVID-19 produced equivalent or better student course performance as compared with pre-pandemic: empirical evidence from a school-wide comparative study. *BMC Med Educ*, 21, 495.
- Zhu N., Zhang D., Wang W., Li X., Yang B., Song J., Zhao X., Huang B., Shi W., Lu R., Niu P., Zhan F., Ma X., Wang D., Xu W., Wu G., Gao G.F., Tan W., & China Novel Coronavirus Investigating and Research Team. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *The New England journal of medicine*, 382(8), 727-733.