PHARMACOPOEIA
Pharmacy Journal

https://nawalaeducation.com/index.php/JP/index
Volume 2 Nomor 1 March 2025
e-ISSN : 3047- 4469
DOI : https://doi.org/10.62872/v3yvk866

Responsibility in Pharmaceutical Practice: Aplication of Beyond Use Date for Compounded Preparations

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INFO ARTICLE

Accepted : February 15, 2025
Revised : February 25, 2025
Approved : March 17, 2025
Published : March 25, 2025

Keywords: *Beyond Use Date, Compounded Preparations , Pharmaceutical Practice*

ABSTRACT

BUD (beyond use date) is very important to maintain the quality, safety, and effectiveness of the drug after the package is opened or blended. The purpose of this study is to evaluate the implementation of BUD (beyond use date) in various pharmaceutical facilities. This study uses the Systematic Literature Review (SLR) method. This study uses a database from scopus. There are three stages carried out in mapping evaluated the application of BUD (beyond use date) in various pharmaceutical facilities, namely : 1) harvesting data, 2) data screening, 3) data analysis and visualization. From the results of data harvesting, 8 articles were published. Based on research with the SLR method that has been carried out, it can be concluded that penerapan Beyond Use Date (BUD) In pharmaceutical preparations, it is a critical aspect that affects the stability, effectiveness, and safety of the drug for patients. Previous studies have shown that adherence to medical standards has a significant impact on the success of therapy. Therefore, this study emphasizes the need for better standardization, increased pharmacist compliance, as well as further research on the impact of the implementation of BUD in clinical pharmacy. The implications of this study are addressed to the researchers and the pharmaceutical practice.

INTRODUCTION

Compounded preparations are an important part of pharmaceutical practice that involves the manufacture of drugs tailored to the individual needs of the patient. This process is often used when commercially available drugs do not meet the specific needs of the patient, such as in the case of pediatric patients or those who have allergies to certain excipients (Briciu et al., 2024; Carvalho & Almeida, 2022) In the context of pharmaceutical education, training on compounded sterile preparations is an important

component of the curriculum, which aims to ensure that pharmacy students have the necessary skills to properly perform aseptic techniques and prepare products that are safe for patients (Dana et al., 2018; Nemec et al., 2016). This training often involves rigorous practical assessment to ensure that students can apply the right techniques in real-world situations (Nemec et al., 2016).

Guidelines from organizations such as the American Society of Health-System Pharmacists (ASHP) and the United States Pharmacopeia (USP) set standards of practice for the preparation of sterile compounds, emphasizing the importance of contamination control, aseptic processing, and quality assurance. ("ASHP Guidelines on Compounding Sterile Preparations.," 2014; Kastango & Bradshaw, 2004). These guidelines aim to reduce the risk of contamination and ensure that the compounded products are safe and effective for use by patients (, 2014). In hospitals, especially in pediatric settings, patients' acceptance of compounded drugs can vary, and factors such as dosage form and ease of swallowing can affect this acceptance (Briciu et al., 2024). Therefore, it is important to identify and address factors that can improve acceptance and treatment outcomes (Briciu et al., 2024). Overall, compounded preparations play an important role in meeting therapeutic needs that commercially available products cannot meet, and proper training and guidelines are essential to ensure the safety and effectiveness of these products.

Compounded preparations have an important role in pharmaceutical services, especially for patients with special needs such as allergies to certain ingredients or specific dosage needs. In situations where there is no approved treatment or even no off-label treatment for patients with rare diseases, pharmacists must concoct drug products to meet the specific needs of such patients (Dooms & Carvalho, 2018). Concocted preparations allow for dosage adjustments and drug combinations that the pharmaceutical industry cannot fulfill, such as for pediatric patients or those who are allergic to certain excipients (Carvalho & Almeida, 2022).

Beyond Use Date (BUD) is the time limit for the use of a drug after it has been formulated or the primary packaging has been opened, which is important for maintaining the quality and safety of the drug (Fernanda & Kusumo, 2023; Nurbaety et al., 2023; Saputri et al., 2023). BUD is different from the expiration date (ED) stated on the drug packaging by the manufacturer (Fernanda & Kusumo, 2023; Iskandar et al., 2022) . Here are the importance of BUD: 1) Ensuring Drug Quality and Stability: BUD ensures that the drug remains in good and stable condition during use (Fernanda & Kusumo, 2023; Saputri et al., 2023) . BUD is very important because it affects the effectiveness and safety of drugs (Gst et al., 2025) 2) Preventing the Use of Unsafe Drugs: Knowledge of BUD helps avoid the use of drugs that have deteriorated or are potentially dangerous after the expiration of the time limit (Nurbaety et al., 2023).Without proper knowledge of BUD, the information provided to patients can be misleading and lead to unsafe use of the drug (Nurbaety et al., 2023). 3) Optimizing Drug Therapy: Correct information about BUD is necessary to avoid negative impacts such as mismedication and decreased drug effectiveness (Iskandar et al., 2022). 4) Reducing Drug Waste: By understanding BUD, pharmacists can reduce drug waste in hospitals due to BUD that is exceeded before all vial contents are used(Hollis et al., 2021) . 5) Important in Drug Compounding: In drug compounding, BUD indicates drug stability and pharmacists are obliged to provide patients with proper BUD information (Cokro et al., 2022). About 75-77% of pharmacists count BUD on drug compounding and mark it on drug labels or packaging (Karuniawati & Hi, 2024).

The public needs to be educated about BUD because it is often only based on the expiration date stated on the packaging (Fernanda & Kusumo, 2023; Saputri et al., 2023). Education about BUD can increase public understanding of the safety of drug use after the packaging is opened (Fernanda & Kusumo, 2023; Iskandar et al., 2022; Rosanti et al., 2023). In conclusion, BUD is essential for maintaining the quality, safety, and effectiveness of the drug after the packaging is opened or blended. Education about BUD is needed to increase public understanding and health workers so that the use of drugs remains optimal and safe.

Problems in the implementation of Beyond-Use Date (BUD) in the field can vary depending on the context, such as in urban food distribution or in extemporaneous medicine. Here are some of the problems identified from related studies: 1) Limited Access to Healthy Foods: Existing food distribution systems tend to be more supportive of the provision of processed foods high in fat, sugar, and sodium, which hinders access to healthier alternatives such as fresh produce (Gittelsohn et al., 2022). 2) Multi-Level Engagement: The implementation of BUD applications in Baltimore attempts to address this issue by involving various levels in the local food system, but challenges in implementing and evaluating its effectiveness remain (Gittelsohn et al., 2022). 3) Financial Sustainability: Although the BUD app is expected to be a viable financial alternative for small shops to increase the stock and sales of healthy foods, sustainability is a key part of the solution. (Gittelsohn et al., 2022). 4) Determination and Implementation of BUD: Many pharmacists define and mark BUDs on drug labels, but only some ensure that patients understand the information (Karuniawati & Hi, 2024). 5) Influencing Factors: Factors such as age, marital status, education level, work experience, and income influence the determination and implementation of BUD by pharmacists (Karuniawati & Hi, 2024). 6) Increasing the Role of Pharmacists: It is necessary to increase the role of pharmacists in ensuring the quality, safety, and effectiveness of drug therapy through better determination and implementation of BUD (Karuniawati & Hi, 2024).

The main problems in the implementation of BUD in the field include challenges in access and distribution of healthy food in urban environments as well as the determination and understanding of BUD in concoctive medicine. Both of these contexts require a more integrated approach and better education to ensure the effectiveness and sustainability of interventions. The importance of this research is to understand more deeply about the practice of implementing BUD (beyond use date) in pharmaceuticals. So the purpose of this study is to evaluate the application of BUD (beyond use date) in various pharmaceutical facilities.

METHODOLOGY

This study uses the Systematic Literature Review (SLR) method. SLR is a synthesis of literature studies that are carried out systematically, clearly, and thoroughly. SLRs are often used to conduct thematic analysis, identify key themes and subthemes in the existing literature, and explore current trends and developments (Oladimeji et al., 2020). The purpose of this method is to help researchers understand more deeply about the research being studied, including why and how the results can be used as a reference for new research. In this study, researchers evaluated the application of BUD (beyond use date) in various pharmaceutical facilities.This study uses a database from scopus. There are three stages carried out in mapping evaluated the application of BUD (beyond use date) in various pharmaceutical facilities, namely:

1. *Harvesting Data.*. At this stage, the researcher harvested data by collecting articles that had been published and indexed by the Scopus indexing agency. To collect publications from this Scopus indexing institution, researchers directly went to the Scopus database. The search for publications was carried out using keywords in this study, including: " pharmaceutical OR practice AND application OR beyond OR use OR date OR for OR compounded OR preparations" with a time span of 2018-2024. In harvesting this data, it is also based on several countries in Southeast Asia, such as Indonesia, Malaysia, and Singapore.

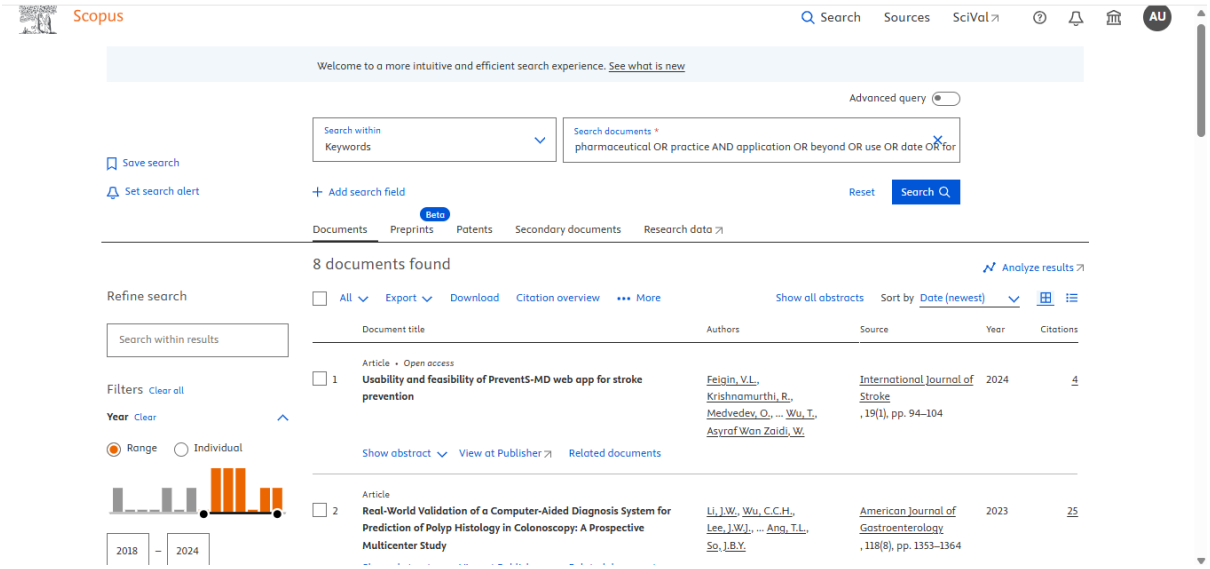

Figure 1. Results of data harvesting 8 articles

From the results of data harvesting, 8 articles were published. Furthermore, the researcher downloads all scientific papers in the form of RIS. Click "Select All", then click "Export" and select "RIS Format". Then it will go to the page as below

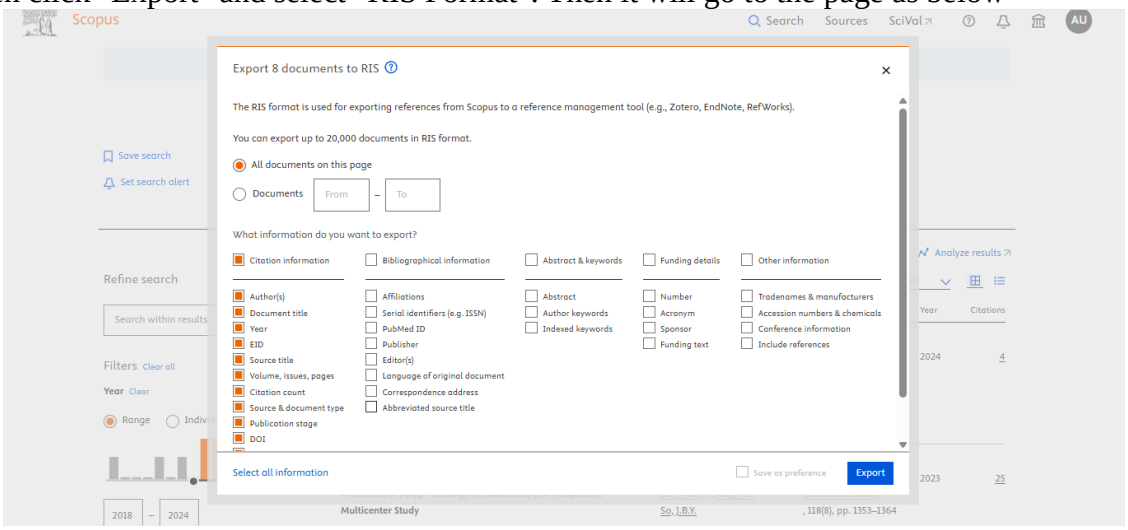

Figure 2. Results of RIS 8 articles

2. Data Screening. Based on the results of data collection obtained from the Scopus indexing agency, there are 8 article publications related to evaluated the application

of BUD (beyond use date) in various pharmaceutical facilities during the 2018-2024 period.

3. Data Analysis and Visualization.. In this data analysis stage, the researcher conducted an analysis of the publications obtained from Scopus at the time of data harvesting. There are several data related to publications that are analyzed, such as the development of publications per year during the 2018-2024 period. Of the three stages, namely the stages of data harvesting, data filtering and data analysis and visualization, can be described as follows:

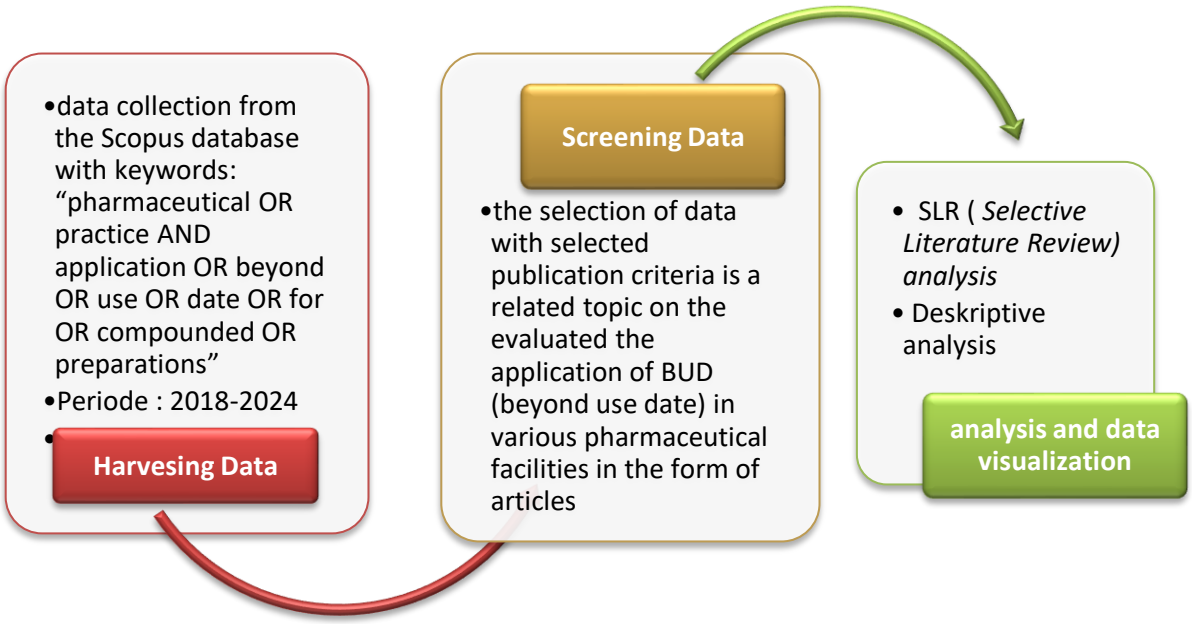

Figure 3. Draft SLR Methodology on Research related to the evaluated the application of BUD (beyond use date) in various pharmaceutical facilities

RESULTS AND DISCUSSION

1. Publication Development

The development of publications in the Scopus journal related to the evaluated the application of BUD (beyond use date) in various pharmaceutical facilities during the 2018-2024 period. In 2019, 2020, and 2021, the number of available journals was stable at 2 documents per year. This indicates that in this period there is consistency in the number of publications or related search results. The year 2022 shows 0 documents, which means that no publication journal results were found this year. This is due to a lack of publications, a change in search methods, or a limitation of the data available in that year. The year 2023 shows an increase to 1 journal, which indicates a recovery after the absence of journals in 2022. In 2024, it also has 1 journal, which means it is stable compared to the previous year but still lower than 2019-2021.

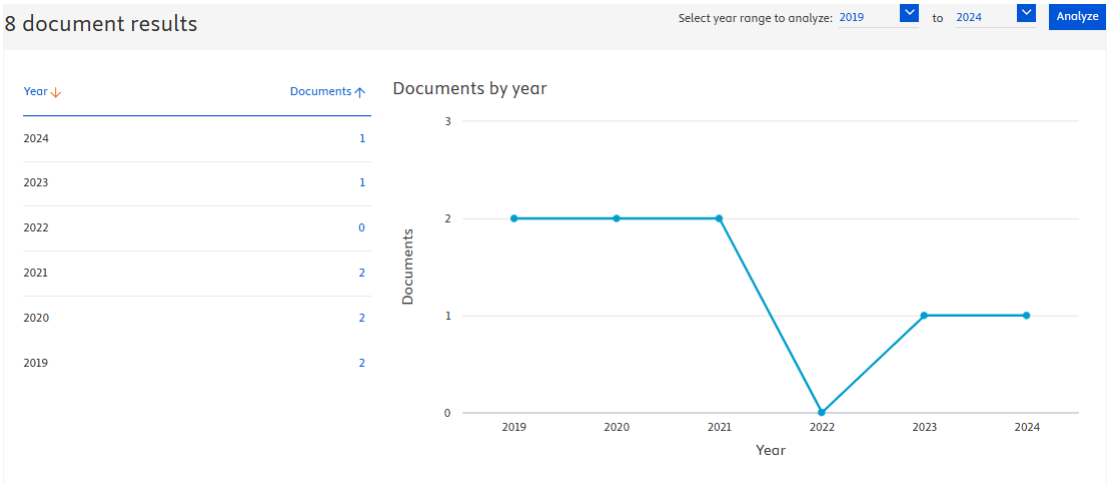

Figure 4. Publication Development Based on Scopus Data for the Period 2018-2024

Data Source : Scopus 2025

The graph above illustrates the a significant decline in 2022 which led to a gap in data. After 2022, there was a gradual recovery, although the number of journals found has not returned to pre-2022 levels. If this trend continues, it is possible that the number of published journals will remain stable or increase slightly in the coming years.

2. Afiliation of The Country Producing Scientific Work

The affiliation of the countries producing this scientific work is within the scope of countries in Southeast Asia, such as Indonesia, Malaysia, and Singapore. Based on the graph produced, it shows the distribution of documents based on affiliation. Tan Tock Seng Hospital has the highest number of publications (about 5-6 documents). The National University of Singapore (NUS) also has significant contributions, including the NUS Yong Loo Lin School of Medicine and the National University Hospital with a slightly lower number of publications. The Faculty of Medicine, Johns Hopkins University, Changi General Hospital, Capital Medical University, Chulalongkorn University, and UNSW Sydney have the same number of publications (2 documents each). This shows that they still have quite an important contribution, although not as much as the top institutions. Most of the publications come from institutions in Singapore, such as Tan Tock Seng Hospital, NUS, and Changi General Hospital. Other institutions from the United States (Johns Hopkins), Australia (UNSW Sydney), China (Capital Medical University), and Thailand (Chulalongkorn University) also contributed, but in smaller numbers.

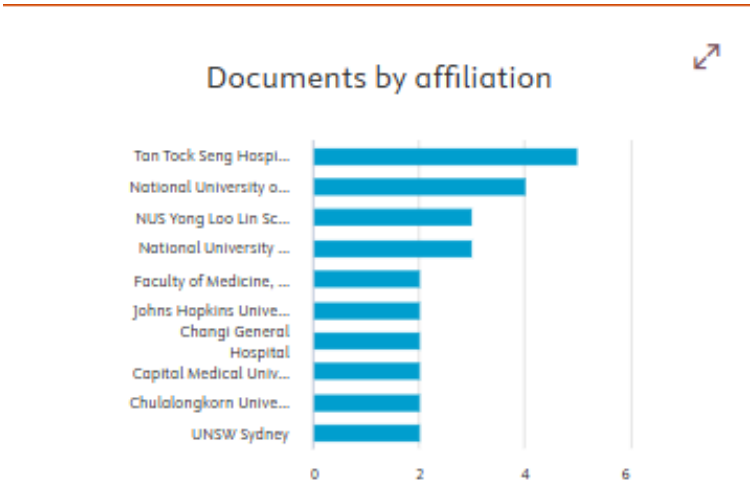

Figure 5. Affiliation of Scientific Paper Producing Countries Based on Scopus Data
Source: Data Scopus 2025

Based on the graph image above, it can be concluded that this graph shows that Tan Tock Seng Hospital and NUS have a dominance in the number of publications, demonstrating their active role in related research. International collaboration is quite wide, with the involvement of institutions from various countries. Institutions with smaller contributions remained important in the research analyzed, although the number of documents was less.

3. Most Cited Articles

Based on the results of harvesting data, data selection (screening data) and data processing on publications related to the evaluated the application of BUD (beyond use date) in various pharmaceutical facilities in the Scopus database. During the period 2018 to 2024, there are 8 journal publications related to the the evaluated the application of BUD (beyond use date) in various pharmaceutical facilities. From Table 1 below, there are eight journal publications related to the evaluated the application of BUD (beyond use date) in various pharmaceutical facilitie.

Tabel 2. Literatur Review Summary

No	Referensi	Judul	Fokus Studi	Metode dan sampel	Hasil
1	(Feigin et al., 2024)	Usability and feasibility of PreventS-MD web app for stroke prevention	PreventS-MD web app for stroke prevention	Methods: This is a mixed-methods cross-sectional two-phase survey using a largely positivist (quantitative and	A total of 99 healthcare professionals (HCPs) from 27 countries took part in the study, with 45% representing low- to middle-income nations. Of these, 10 HCPs were previously involved in the development of PreventS and thus were excluded from the survey. Among the remaining 89 participants, 69 agreed to

				qualitative) framework.	take part in the initial phase of the survey, with 59 completing it (yielding an 86% response rate). In the second phase, 58 participants completed the survey, resulting in an 84% response rate. Usability testing through the System Usability Scale (SUS) indicated strong usability for the prototype (mean score of 80.2; 95% CI [77.0–84.0]) and excellent usability for the finalized PreventS-MD version (mean score of 81.7; 95% CI [79.1–84.3]). These scores were consistent regardless of participants' age, gender, professional experience, or specialty. A one-month follow-up with patients showed full adherence (100%) to recommendations and high satisfaction with PreventS-MD. In conclusion, the PreventS-MD web application demonstrated high usability, feasibility, and user satisfaction among both HCPs and individuals at risk for stroke or cardiovascular disease.
2	(Li et al., 2023)	Real-World Validation of a Computer-Aided Diagnosis System for Prediction of Polyp Histology in Colonoscopy : A Prospective	A Prospective Multicenter Study	Method type: the researchers performed a prospective, multicenter study comparing CADx and endoscopist predictions of polyp	Between March 2021 and July 2022, a total of 661 eligible polyps were removed from 320 patients aged 40 years and older. The computer-aided diagnosis system (CADx) achieved an overall accuracy rate of 71.6% (95% confidence interval [CI]: 68.0–75.0), which was slightly lower than the

		Multicenter Study		histology in real-time colonoscopy.	75.2% accuracy rate achieved by endoscopists (95% CI: 71.7–78.4), with the difference being statistically significant (P = 0.023). In detecting neoplastic polyps, CADx had a sensitivity of 61.8% (95% CI: 56.9–66.5), compared to 70.3% (95% CI: 65.7–74.7) for endoscopists (P < 0.001). The level of agreement between CADx and endoscopists in predicting polyp histology was moderate, with an 83.1% agreement rate and a kappa value of 0.661. Notably, when both CADx and the endoscopists provided matching predictions, the diagnostic accuracy improved to 78.1%
3.	(Tan et al., 2021)	Exploring the role of trauma in underpinning sexualised drug use (‘chemsex’) among gay, bisexual and other men who have sex with men in Singapore	the role of trauma in underpinning sexualised drug use (‘chemsex’) among gay	Methods: qualitative study investigates life histories of trauma, and proposes a framework to better situate the factors driving SDU among treatment-experienced GBMSM	The result is study proposes the role of trauma and the preconditions underpinning them in motivating SDU among a sample of largely substance use treatment-experienced GBMSM in Singapore. Interventions that provide support for GBMSM seeking treatment for SDU should provide trauma-informed care to address the complex barriers to treatment effectiveness.
4.	(Han et al., 2021)	HIV treatment outcomes among people who acquired HIV via	HIV treatment outcomes among people who acquired HIV	Method : investigated HIV treatment outcomes among people who	Among 622 people who inject drugs (PWID) from 12 Asia-Pacific countries, 93% were male, with a median age of 31 years (IQR: 28–34) at the start of antiretroviral therapy

		injecting drug use in the Asia-Pacific region: a longitudinal cohort study		acquired HIV via injecting drug use in the TREAT Asia HIV Observational Database (TAHOD) between January 2003 and March 2019..	(ART). The median CD4 count before initiating ART was 71 cells/μL. CD4 levels showed consistent improvement over time, with an average increase of 401 cells/μL (95% CI: 372–457) observed at year 10 among 78 individuals. Smaller gains in CD4 counts were linked to higher pre-ART CD4 levels and higher HIV viral loads during follow-up. Among 361 PWID who had at least one viral load test six months post-ART initiation, viral suppression (VS) rates were 82% at two years, 88% at five years, and 93% at ten years. Over 3,347 person-years of follow-up, 52 new AIDS-defining illnesses and 50 deaths were recorded, yielding an incidence rate of 3.05 per 100 person-years (95% CI: 2.51–3.70). Factors such as a prior diagnosis of AIDS or tuberculosis, lower current CD4 counts, and ART adherence below 95% were associated with a higher risk of experiencing a new AIDS-related event or death.
5.	(Kim et al., 2020)	Changes in serotype distribution and antimicrobial resistance of Streptococcus pneumoniae isolates from	Emergence of drug-resistant non-vaccine serotypes	Method: Serotyping and antimicrobial susceptibility tests of 850 pneumococcal isolates were performed.	The Results is The proportions of isolates with serotypes covered by 13-valent pneumococcal conjugate vaccine (PCV13) were 37.0% in Korea, 53.4% in China, 77.2% in Malaysia, 35.9% in the Philippines, 68.7% in Singapore, and 60.2% in

		adult patients in Asia: Emergence of drug-resistant non-vaccine serotypes			Thailand. Major serotypes were 19F (10.4%), 19A (10.1%), and 3 (8.5%) in 2012-2017, with different serotype distributions in each country. Macrolide resistance in pneumococci was high (66.8%) and prevalence of multidrug resistance (MDR) also remained high (50.8%). MDR non-PCV13 serotypes such as 11A, 15A, 35B, and 23A have emerged in Asian countries. This study showed the persistent prevalence of 19F and 19A with a noteworthy increase of certain non-PCV13 serotypes in Asian countries. High prevalence of macrolide resistance and MDR was also found in pneumococcal isolates.
6.	(Bairy, 2020)	Using Kinetic EGFR for Drug Dosing in AKI: Concordance between Kinetic EGFR, Cockroft-Gault Estimated Creatinine Clearance, and MDRD EGFR for Drug Dosing Categories in a Pilot Study Cohort	Using Kinetic EGFR for Drug Dosing in AKI	Method: In the pilot study published previously, 80 adult patients with a significant change in Cr level after admission to the acute medical ward were classified as per the Acute Kidney Injury Network (AKIN) criteria and compared to a KEGFR-	The result is the concordance between CGeCRCL and KEGFR for drug dosing categories was only 62%, with 27 (90%) of the 30 discordant subjects falling into a higher EGFR category when KEGFR was used. The agreement between KEGFR and CGeCrCl was also unsatisfactory. There was better concordance (75%), but the agreement was also not satisfactory between MDRD EGFR and KEGFR for the drug dosing categories. Conclusions: In AKI, compared to CGeCrCL, using KEGFR may affect drug dosing

				based criterion. The CG equation and the MDRD equation were applied retrospectively to the same dataset, and the concordance of the EGFR categories between the 3 methods was studied.	significantly by changing the EGFR category.
7.	(Tran et al., 2019)	Modeling research topics for artificial intelligence applications in medicine: Latent dirichlet allocation application study	artificial intelligence applications in medicine	Methods: bibliographic data and abstract contents of publications published between 1977 and 2018 from the Web of Science database.	The result is The applications of AI have mainly impacted clinical settings (enhanced prognosis and diagnosis, robot-assisted surgery, and rehabilitation), data science and precision medicine (collecting individual data for precision medicine), and policy making (raising ethical and legal issues, especially regarding privacy and confidentiality of data). However, AI applications have not been commonly used in resource-poor settings due to the limit in infrastructure and human resources.
8.	(Koh et al., 2019)	Adherence to surveillance guidelines following colonic polypectomy is abysmal	surveillance guidelines following colonic polypectomy	Methods : A review of a prospectively collected colonoscopy database in a single tertiary institution was	In 2008, a total of 419 colonoscopies involving polypectomies were carried out. The median age of the patients was 60 years (ranging from 26 to 95 years), with the most frequent finding being tubular adenoma with low-

				conducted for all patients who underwent polypectomy in 2008.	grade dysplasia, observed in 291 cases (69.5%). Adherence to the post-polypectomy surveillance guidelines set by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES)—which consider factors like polyp characteristics and bowel preparation quality—was notably low at just 13.8% (58 patients). A total of 107 patients (25.5%) underwent follow-up endoscopy earlier than recommended, though none of these cases resulted in a malignancy diagnosis. On the other hand, 192 patients (45.8%) had their surveillance delayed beyond the recommended timeframe or were lost to follow-up. Among this group, two patients were later found to have developed cancer, diagnosed three and five years after their suggested surveillance dates. Conclusion: Compliance with recommended post-polypectomy surveillance guidelines was found to be significantly low.

Based on table 2, it shows that this research mostly studies in the table examines the innovation and effectiveness of new tools or methods in medical and pharmaceutical practice. Key topics include medical technology (PreventS-MD, CADx for polyp prediction, AI in medicine), infectious diseases and treatment (HIV, antibiotic resistance Streptococcus pneumoniae), as well as public health and policy (adherence to post-polypectomy surveillance guidelines, impact of trauma on drug use behavior). The research methods used include: 1) Dominant quantitative approach, especially in clinical data-based studies, diagnostic tests, and system validation. 2) Qualitative methods are used in social and behavioral studies, such as studies of trauma and drug use.3) Diverse research designs including multinational prospective studies, longitudinal observational studies, and bibliometrics-based analyses. The Main Results and Implications of some of

these studies are; 1) The PreventS-MD Web App shows high usability and positive acceptance by medical personnel and patients.2) CADx for colon polyps has lower accuracy than that of doctors, but still contributes to improving diagnostic outcomes when used together. 3) Trauma plays a role in drug use behavior and demonstrates the need for a trauma-based approach in interventions. 4) HIV patients infected through drug use experience an increase in CD4 after ART, but still face a high risk of AIDS and related death. 5) Antibiotic resistance of Streptococcus pneumoniae remains high, with the emergence of resistant non-vaccine serotypes. 6) KEGFR for drug doses in AKI provides significant differences in classification compared to other methods, indicating potential impacts in drug administration. 7) AI in medicine is growing rapidly but still has limitations in developing countries due to inadequate infrastructure. 8) Adherence to post-polypectomy surveillance guidelines is very low (13.8%), which can lead to delayed cancer diagnosis. Gaps in this research include; 1) Lack of research in developing countries for AI and other medical technology applications. 2) Further research is needed on factors influencing adherence to medical guidelines (such as post-polypectomy surveillance and BUD in pharmaceuticals). 3) There is a need for a personalization-based approach in biomarker-based medicine and predictive technologies.

DISCUSSION

Aplication of Beyond Use Date for Compounded Preparations

Based on the results of the table analysis, some of the main solutions There is an important point in the context of BUD (beyond use date) is that as in the study of antibiotic resistance which shows changes in the effectiveness of drugs due to external factors, the stability and safety of the compounded drugs are also influenced by storage factors and time of use and as in the study of HIV and AKI, more accurate measurements in determining the dosage and time of use of drugs are very important to avoid side effects or resistance. The stability and safety of the compounded drug is greatly influenced by the storage conditions and time of use. Factors such as temperature, humidity, and light exposure can affect the physical and chemical stability of these medications.

Storage Factors that Affect the Stability of Drugs include: 1) Temperature and Humidity: Inappropriate temperature and humidity can accelerate the degradation of the active ingredients in the drug, reducing the effectiveness and safety of the drug (Alanazi, 2024; González-González et al., 2022). For example, studies show that drugs stored at higher than recommended temperatures can experience a decrease in the concentration of the active ingredient (Pietsch et al., 2022) 2) Light Exposure: Light exposure can also affect the stability of the drug, especially for light-sensitive drugs (Alanazi, 2024). 3) Special Storage Conditions: Some drugs require special storage conditions, such as refrigeration, to maintain their stability (A.N. et al., 2023; González-González et al., 2022) . Methods to Improve Stability include; 1) Use of Co-Crystals: This technique can improve the stability of moisture-sensitive drugs by reducing their hygroscopicity (Dhondale et al., 2023) . 2) Predictive Stability Studies: This method allows for faster and more efficient prediction of the long-term stability of the drug, reducing chemical waste (González-González et al., 2022, 2023). Based on several of these sources, it can be concluded that the stability of concocted drugs is greatly influenced by storage conditions such as temperature, humidity, and light exposure. Methods such as the use of co-crystals and predictive stability studies can help improve drug stability. It is important to follow proper storage guidelines to ensure the effectiveness and safety of the medication.

CONCLUSION

Based on research with the SLR method that has been carried out, it can be concluded that The application of Beyond Use Date (BUD) in pharmaceutical formulations is a critical aspect that affects the stability, effectiveness, and safety of drugs for patients. Previous studies have shown that adherence to medical standards has a significant impact on the success of therapy. Therefore, this study emphasizes the need for better standardization, increased pharmacist compliance, as well as further research on the impact of the implementation of BUD in clinical pharmacy.

Research Implications

The implications of this research are;

1. For Researchers

   This study shows that there is still a gap in research regarding the impact of suboptimal BUD implementation. Therefore, further research needs to be conducted to evaluate the pharmacological and clinical impacts of various methods of determining BUD. As well as studies on the use of AI in medicine, there is an opportunity to develop technology-based systems (e.g. AI or data-driven algorithms) to assist pharmacists in establishing more accurate BUDs.
2. The Pharmaceutical practice

   Improved patient safety with proper BUD implementation can prevent the use of medications that are already unstable, thereby reducing the risk of side effects, toxicity, or decreased therapy effectiveness.

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