

Analysis of the evolution of clinical pharmacy

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Author contributions

Dong KJ conceived the concept for this paper and contributed mainly to its completion. Wang PS refined the part of philosophical analysis. All authors have read and approved the final manuscript.

Competing interests

The authors declare no conflicts of interest.

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Abbreviations

ACPE, Accreditation Council for Pharmacy Education; TCM, traditional Chinese medicine.

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Abstract

Background: Since its inception, clinical pharmacy has played an increasingly significant role. However, compared to the successful establishment of pioneering Western countries, the outcomes of later-developing countries, despite substantial investments, have been less than ideal. **Methods:** This article adopts a two-tier comparison approach and a philosophical integration method. **Results:** At the first-tier level, this article examines the current status of clinical pharmacy in advanced countries, highlighting the differences and commonalities among the models adopted by countries such as the USA, the UK, and Japan. Subsequently, at the second-tier level, it analyzes the evolutionary trajectory of the “human-medication” relationship from a sociological perspective, derives the driving force of organizational “common goal orientation” from a management perspective, and identifies three types of “macro-micro inconsistencies” from a policy perspective: disruptive, counter-pulling, and insoluble. To penetrate and converge the above dimensions, this article integrates philosophical considerations from the theory of knowledge. Transitioning from multi-faceted interpretations to ontological research, it points out that the essence of clinical pharmacy development lies in the expansion of World 3 and the complementation of new Interactional Expertise. **Conclusion:** Clinical pharmacy is a combination of total increase in statistical knowledge and individualized precise application. Late-developing countries, including China, must especially recognize this essence when formulating and implementing relevant policies.

Keywords: clinical pharmacy; development mechanism; theory of knowledge

Background

Since the last century, with the emergence of complex issues such as industrialization, urbanization, human aging, and environmental pollution, our human being has faced increasingly prominent and urgent challenges in the medical field, and clinical pharmacy emerged as the times require. It is a practical need to cope with the increasingly serious problem of medication and improve the efficiency of patient services in fighting against health threats. It is also an inevitable trend of medical science, especially the improvement of pharmacy itself, and the cross-disciplinary development with other disciplines [1]. Based on the study of Russell R. Miller, this new breed of pharmacists is patient-oriented rather than drug-product-oriented. The discipline arose out of dissatisfaction with old practice norms and the pressing need for a health professional with a comprehensive knowledge of the therapeutic use of drugs. The clinical pharmacy movement began at the University of Michigan in the early 1960s, but much of the pioneering work was done by David Burkholder, Paul Parker, and Charles Walton at the University of Kentucky in the latter part of the 1960s. Clinical pharmacology is a professional discipline that combines basic pharmacology and clinical medicine. Its development began in the early 1950s, primarily as a result of the efforts of Harry Gold [2].

As the birthplace of clinical pharmacy, after nearly 70 years of cultivation and promotion, developed countries led by the USA have formed mature and advanced manners in clinical practice, clinical education, and other fields, and have achieved fruitful breakthroughs. According to the American College of Clinical Pharmacy, clinical pharmacy is a pharmaceutical field concerned with the scientific research and practice of rational drug use [3]. It involves pharmacists utilizing their professional knowledge, theories, techniques, methods, instruments, as well as their unique professional thinking and judgment abilities, to provide assistance to doctors, nurses, and patients in various aspects of drug therapy [4].

This paper intends to study the development history of advanced clinical pharmacy services, explore the mechanisms of its evolution process, and provide references for the high-quality development of clinical pharmacy services in late-developing countries, which has certain theoretical and practical values.

Current status of clinical pharmacy in advanced countries

Main models of clinical pharmacy development

After the birth of clinical pharmacy, developed countries have basically formed three relatively mature models through long-term and sufficient expansion, namely the American model, the British model, and the Japanese model (Table 1).

The USA was the first country to initiate and establish research in clinical pharmacy. In 1948, the American Association of Colleges of Pharmacy proposed the establishment of a clinical pharmacy system

centered on rational drug use and the establishment of clinical pharmacists. In 1957, Professor Donald E. Francke of the University of Michigan College of Pharmacy first proposed the scheme of a “clinical pharmacy program” in colleges and universities, suggesting that hospital pharmacists complete a six-year Pharm.D. curriculum and formulated the Pharm.D. syllabus, thereby establishing the clinical pharmacy program. Since then, pharmaceutical education has shifted from the traditional “drug-centered” approach to a “patient-centered” approach, with the main goal of cultivating clinically applied talents centered on patients. By 1974, the Accreditation Council for Pharmacy Education (ACPE) clearly issued new standards requiring Pharm.D. degree recipients to complete 1,500–1,800 h of “clinical internship” training, in other words, requiring both clinical theoretical knowledge and practical experience, and incorporated this as a basic requirement into the syllabus. Following the advocacy of American clinical pharmacy experts Hepler and Strand in 1990, “pharmaceutical care” became an even higher development direction. In 1993, ACPE decided to make the Pharm.D. degree the sole qualification requirement for pharmacists to take up their posts. Since June 1, 2000, all pharmacy and medical school institutions accredited by ACPE have been required to change the original (4 + 2) education model to the (2 + 4) model, which consists of 2 years of pre-pharmacy studies followed by 4 years of Pharm.D. professional coursework. Other non-pharmacy majors such as biology and chemistry can apply for the Pharm.D. degree through the Pharm CAD exam after obtaining a bachelor’s degree, following a (4 + 4) model. Currently, there are over 600 universities in the USA accredited by ACPE to offer Pharm.D. direct education and continuing education training. The maturity and perfection of American standards have become a reference for other countries. Pharm.D. graduates in the USA mainly enter the ASHP-administered residency pharmacist program, where they still need practical and research training before they can work. After 2020, the American model exhibits a “bio-psycho-social” triple helix characteristic as a whole [5].

The British model embodies the characteristic of balancing “theoretical depth and clinical depth”. In 1978, the world’s first postgraduate clinical pharmacy training program was established in the UK. This pilot education project, located in Manchester, extended the original undergraduate pharmacy program, allowing students to obtain a postgraduate diploma (PG certificate/diploma of clinical pharmacy) in clinical pharmacy through a (4 + 1 ~ 2) study mode. This model was later optimized and solidified as the training mechanism for clinical pharmacists, featuring a 4 ~ 5 year combined undergraduate and postgraduate program. After the first 4 years of coursework, students undergo a one-year “pre-registration training”, which involves a one-year internship in a community pharmacy setting or hospital pharmacy. Following successful completion of the General Pharmaceutical Council’s access exam and registration, they can become pharmacists. The combined undergraduate and postgraduate pharmacy education is primarily conducted in nearly 30

Table 1 Several models of clinical medical service development in developed countries abroad

	American model	British model	Japanese model
Development period	From the 1950s to the present	From the 1960s to the present	From the 1980s to the present
Characteristic	A bio-psycho-social model	A community service – deepening model	A highly synergistic model
Education system	Pharm.D. 2 + 4 Emphasize Master’s and Doctoral degrees	4 + 1 or 4 + 2 Mainly clinical master degrees	4 + 2 Mainly bachelor degrees Longer training cycle
Registration requirements	The only recognized qualification	Registration + clinical practice = clinical pharmacist	Registration + clinical practice = clinical pharmacist
Scope of services	All	Clinical service-oriented	All
Rights & interests	Suggested prescription rights	Prescription rights	Without prescription rights, but with pharmacist service fees

universities authorized by the General Pharmaceutical Council, with universities such as the University of Nottingham, University College London, and Cardiff University offering additional doctoral programs in clinical pharmacy. Although UK law does not mandate the presence of clinical pharmacists in hospitals, a significant number of clinical pharmacists are still deployed in most public hospitals of the National Health Service, accounting for 10% of the health technicians in the UK. The UK emphasizes the provision of high-quality “pharmaceutical care”, which includes pharmacy ward rounds, prescription review, pharmaceutical care, medication education, budget control, and participation in drug therapy and assessment, etc. In 2003, UK pharmacists were also granted prescribing rights, with a broader scope and authority than American pharmacists, covering specialized groups such as women and children, anti-infectives, oncology, stroke, surgery, and more. Nonetheless, 80% of clinical pharmacists primarily work in community pharmacies, with only around 20% employed in hospital pharmacy departments [6].

The Japanese model has absorbed the strengths of both the British and American models while developing its unique characteristics. Firstly, recognizing that mere drug information services could not reverse the lag in the development of pharmacy in Japan, the country began to appreciate the importance of “clinical practice” after the 1990s. Consequently, the training model shifted from the conventional “4-year coursework + pharmacist qualification exam” for general pharmacists to a “4-year bachelor’s degree + 2-year clinical training” program leading to a specialized master’s degree in clinical pharmacy. In 1973, the Graduate School of Pharmaceutical Sciences at Kitasato University produced Japan’s first cohort of clinical master’s degree students. In 2002, the Japan Pharmaceutical Association proposed a 6-year clinical pharmacy education reform, which was implemented from 2004 onward. This system comprises “4 years of coursework + national theoretical exam + 2 years of clinical internship + national pharmacist qualification exam”, culminating in clinical pharmacist certification. For those seeking a graduate degree, they must build upon the first 4 years of coursework and apply for the graduate entrance exam after completing the 6-year clinical education program. Japan’s clinical pharmacist education system balances academic advancement with clinical practice, albeit with a longer duration. The advantage lies in the depth and breadth of clinical pharmacists’ work, encompassing various aspects of the pharmacy department upon entering hospitals, and enabling them to charge for pharmacist services. Clinical pharmacists enjoy a high level of involvement and collaboration with medical team [7].

After decades of development, clinical pharmacy has been recognized all over the world, and even the African regions have begun to build corresponding clinical pharmacist teams [8]. Due to the imbalance of the world’s economic and technological development, there are not only differences but also many commonalities among regions.

The common characteristics of clinical pharmacy development

The universal features of clinical pharmacy development in developed countries encompass a strong emphasis on the professionalism and training of clinical pharmacists, a patient-centric approach to pharmaceutical care, interdisciplinary collaboration and integrated treatment, robust policy frameworks and regulatory systems, as well as sustained research innovation and technological applications. These attributes collectively drive the rapid and continuous advancement of clinical pharmacy in developed nations. These characteristics are actually developed and formed around the problems that need to be addressed.

From the perspective of its development origins, the rise of clinical pharmacy is primarily aimed at addressing the issue of “rational drug use” [9]. According to the World Health Organization, over 50% of medications globally are prescribed, dispensed, or sold irrationally, and 50% of patients fail to use them correctly. In 1938, the USA used industrial diethylene glycol as a solvent for sulfanilamide, leading to the deaths of 107 people after clinical application. In the 1950s, incidents involving organic tin-containing capsules used for

anti-infection and chloramphenicol resulted in significant accidents, with 217 people poisoned (including 102 deaths) and over 1,000 fatalities, respectively. Concurrently, in Western Europe, the new drug “thalidomide” introduced in 1956 as a sedative for women’s pregnancy symptoms resulted in the birth of 8,000 to 10,000 children with limb deformities. Among long-term medications, 8-hydroxyquinoline caused blindness or paralysis in over 8,000 people in Japan, and bismuth salts caused central nervous system damage in over 1,000 people in France. Therefore, this article argues that rational drug use is a comprehensive proposition put forward under the two dimensions of accurate medication and medication safety. It represents a reflection and transformation in response to the urgent concern over a series of problems, including overdosing, incorrect medication use, adverse drug reactions, and drug-induced injuries, which bring immense pain, burden, and harm to patients, families, and society. On the basis of enhancing drug safety, American clinical pharmacy has further proposed “pharmaceutical care” [10]. Furthermore, the American model also emphasizes drug technology innovation and practice leadership, etc. [11].

From the current actual state of development in clinical pharmacy, two main aspects can be identified. The first aspect is medication-related outcomes. It encompasses various sub-disciplines under the pharmaceutical perspective, including pharmaco-economics, genomics, risk prevention and emergency medication, pharmaceutical information services, evidence-based pharmacy, medication education and monitoring, and clinical pharmacy in traditional Chinese medicine (TCM). Even including the application of some computational algorithms [12]. But in terms of purpose, this article posits that these can be categorized into four quadrants: efficient medication, precise medication, risky medication, and cost-effective medication. Rational drug use refers to the efficient and economical use of drugs based on safety [13]. As illustrated in Figure 1.

The second aspect focuses on the implementation means from the perspective of medication services, which entails the type of services that need to be provided by the pharmacist-led pharmaceutical service personnel system. The first stage revolves around “medication”, while both the second and third stages center on “Human” (Figure 2). Among them, the second stage represents the preliminary phase of clinical pharmacy, where “comprehensive pharmaceutical improvement centered on people” emphasizes clinical internships, proximity to patients, and improved services. The third stage marks the clinical pharmacy phase [14]. From this stage onward, especially discussions surrounding the most prevalent talent cultivation pathway of clinical pharmacist education (as mentioned earlier), as well as corresponding regulations and supporting measures, have all evolved around this aspect. The latter primarily follows an organizational behavior perspective, optimizing and integrating various aspects, ranging from the earliest “clinical pharmacist assistance + clinician” model to various locally adapted innovations such as “clinical pharmacist-led pharmaceutical services + clinician-led diagnostic and treatment services”.

Based on the analysis of these two aspects, the goal of medication use is to shift from risky medication (first stage) towards efficient and rational medication (second stage), ultimately achieving precise medication (third stage). From a long-term perspective, humanity has long been in the stage of risky medication, with the second stage only beginning in modern times. From a short-term perspective, for each disease, the initial stage is characterized by risky medication, which is then continuously adjusted based on practice to improve rationality and economy. Therefore, the core issue lies in facilitating the breakthrough from the first stage to the third stage. In other words, it is a matter of path selection.

Moreover, with the deepening of clinical pharmacy research, several new common characteristics have emerged:

(1) As the world’s population ages, including in developing countries, there is a profound concern for medication use in special populations such as the elderly [15]. Complex situations combining major diseases with special populations have become a focus of

clinical pharmacy research, with numerous empirical studies conducted in this regard [16, 17].

(2) With the advent of the information age in the 21st century, the ways of pharmaceutical information services have diversified and enriched compared to the early stages of clinical pharmacy [18, 19]. Research on cutting-edge technologies like ChatGPT and related algorithms has become a frontier in this field [20]. Intelligent clinical information services are gradually emerging as an independently developing new branch [21]. China is no exception, leveraging data and knowledge integration, building smart platforms, and utilizing various means such as WeChat official accounts and Internet + to support remote pharmaceutical services, especially for chronic diseases and pharmaceutical consultations, which can provide positive and timely feedback [22, 23].

Mechanisms of developed countries' clinical pharmacy

The emergence and development of clinical pharmacy are inevitable outcomes of technological progress and improved living standards. Its promotion in various countries is also closely related to their material and cultural conditions. On the whole, current research on clinical pharmacy is primarily conducted from the following perspectives.

Sociological perspective

The sociological perspective is the earliest dimension noted in clinical pharmacy research. Clinical pharmacy emphasizes this transformation as being “patient-centered”. Logically speaking, even traditional

pharmacy should be, and inherently is, “patient-centered”. However, within the social network, due to the demands of individual job roles, this principle has gradually become alienated, resulting in the ultimate goal being decomposed into numerous process goals, with each job role transforming into a “process role”. As a result, we observe an evolutionary feature within the healthcare system, where over time, the focus has shifted from “disease-centered”, “physician and hospital-centered”, and “medication management-centered” to the “patient-centered” approach of clinical pharmacy. Combining Figure 1 and 2, this evolutionary characteristic represents the traces left by the tuning parameters in the current process of focusing on both “human” and “medicine”, ultimately achieving a compromise and sublimation (Figure 3).

In this dialectical upward movement, there are spiral fluctuations around the balanced oblique axis between “human (patient)” and “medicine (medication)”. In other words, the rise of clinical pharmacy represented by “patient-centeredness” is indeed a step forward in medical trends. However, it does not mean that it will become an ultimate and unchanging trend. During a certain period, the focus may shift to medication (or diagnostic and treatment methods) as the core; while in another period, it may revert to centering on humans (patient experience). Looking into the future, the current advanced stage of clinical pharmacy as the mainstream development trend, as explored in Western developed countries, precisely involves discovering and creating new drugs through the interaction between pharmacists and patients in clinical pharmacy. This precisely proves this point.



Figure 1 Main dimensions of issues concerned in clinical pharmacy

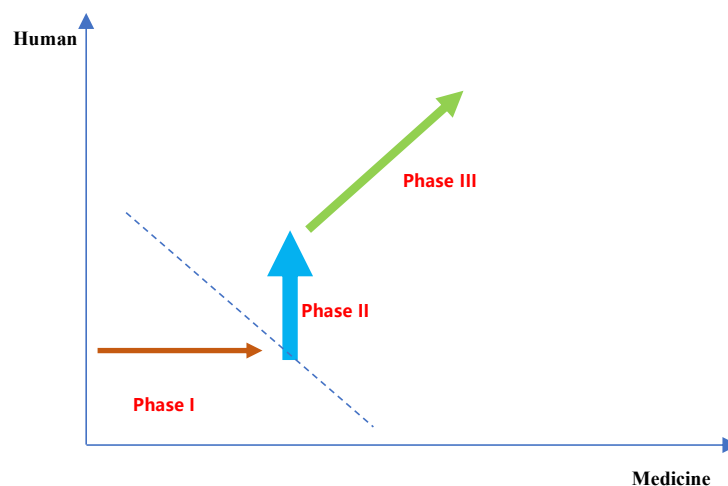


Figure 2 Three Stages of dominant ideologies in the development of clinical pharmacy

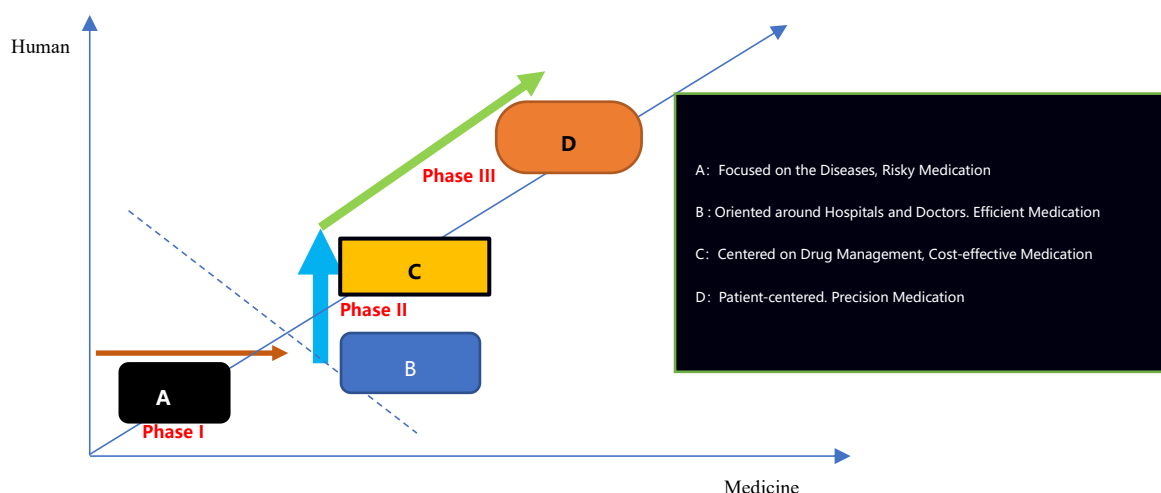


Figure 3 Existing development trajectory and key focuses of clinical pharmacy

The sociological perspective is conducive to understanding the reasons for the emergence of the discipline of “clinical pharmacy” and can make certain judgments about its development trends and directions. However, the sociological perspective falls short when it comes to understanding the developmental process of clinical pharmacy. For instance, why did the USA take the lead in proposing clinical pharmacy? In other words, why did the USA initiate the shift in focus from “drug-centric” to “patient-centric” pharmacy? Why were developed countries the pioneers of this transformation? Developing countries share equal concerns for human health, so why didn't they take the lead, and why do they still find themselves in a position of following in the footsteps of “clinical pharmacy” after decades of implementation? Therefore, an examination from an economic management perspective is necessary.

Management perspective

The management perspective is primarily based on the theoretical logic of organizational behavior, which can be further divided into two aspects. One aspect is the organizational dimension: it emphasizes that due to the complexity of social division of labor, the stronger the professionalism becomes, the greater the difficulty of collaboration between different divisions, leading to the need for frequent lubrication and incentives for the collaboration and interaction between various elements to achieve an effect of “1 + 1 + 1 > 3”.

Prior to the emergence of clinical pharmacy, the primary treatment collaboration model was generally “doctor + nurse → patient → pharmacist”, where pharmacists had a low presence. Beyond dispensing medications, they typically provided medication instructions during the medication pickup process. However, clinical pharmacy emphasizes that pharmacists should enhance communication with patients, shortening the communication distance, and play a role within the medical micro-organization through a “strongly embedded” approach. This transforms the structure into “doctor + clinical pharmacist + nurse → patient” or, even further, a new attempt at a normalized health maintenance model of “patients and potential patients → clinical pharmacist + doctor + nurse”. This change has greatly enhanced the precision and efficiency of clinical decision-making (Figure 4).

The other aspect is the behavioral dimension. The work of pharmacists has expanded from routine activities such as formulation and medication management to a diverse range of behaviors that are more beneficial to patients. These include but are not limited to: prescription review and commentary, medication reconciliation, pharmaceutical care, medication consultation, medication education and science popularization, adverse drug event monitoring, precision medication services, and medication therapy management, etc. [24]. Strengthening these behaviors is conducive to pharmacists leveraging their professional knowledge to provide references for doctors and

avoid issues such as improper medication use. The prerequisites to address include further developing pharmacists' capabilities, as well as addressing their motivations and social environmental factors. On one hand, pharmacists' compensation and social recognition can be improved through laws, regulations, and authorizations. On the other hand, it is necessary to overcome various related challenges within the existing hospital system, such as title evaluation and the collection of pharmacist service fees. In regions other than developed countries, where the clinical pharmacist system is introduced later, there is also the issue of “invasiveness” – the clinical domain, which originally belonged to clinicians, feels invaded by pharmacists, while pharmacists may feel like “guests” in this environment. Overcoming this behavioral and psychological challenges will also take time and reshape contexts.

The management perspective also concisely addresses the necessity of clinical pharmacists to a certain extent and explains the obstacles and difficulties faced by the clinical physician team. However, the management perspective provides insufficient explanation for understanding the differences in the developmental process of clinical pharmacy. A typical question arises: what are the fundamental differences between the American model, the British model, and the Japanese model? Is it merely a matter of difference between the initiator and followers? In other words, why haven't other developed countries like Germany and France developed their unique models? Are economic indicators, such as per capita income or per capita healthcare expenditure, the determinants of a country's clinical pharmacy development? How is the supply and demand relationship for clinical pharmacists determined? Should it be based on the proportion of clinical pharmacists in developed countries? Furthermore, when developing countries acknowledge the importance of clinical pharmacy and start catching up, which model should they choose to emulate? The management perspective explains the reasons for the effectiveness of clinical pharmacy development in pioneering countries, but it struggles to answer the question of possible catch-up paths for later-developing countries.

Policy-science perspective

In a sense, the sociological perspective represents a macro trend and demand, while the management perspective represents a micro path of change and a means of satisfaction. But from the perspective of policy science, only through coordination between the two can optimal results be achieved. Developed countries abroad have adopted different mechanisms to achieve their respective coordination (Figure 5). The American model mentioned earlier is unique in its high degree of consistency between the macro and micro levels. That is, there is a high degree of synchronization between changes in mass demand at the social level and organizational recognition at the management level. Not only does the entire society begin to realize the importance

of shifting from “medication” to “people” and actively cooperate to implement educational and certification systems consistently, but within the medical team, doctors and nurses also recognize the scarce value of clinical pharmacists. Therefore, the advancement of the American model is carried out in a coordinated manner, which we can define as “consistent type”.

The British model, on the other hand, prioritizes the demonstration of the new functions of “clinical pharmacy” services in micro-practices before gradually assisting and optimizing related supporting social systems and facilities. The reason this model can be smoothly implemented is that the British society, similar to the development level of the USA, has inherent conditions for directly offering clinical pharmacy services, such as directly granting clinical pharmacists prescribing rights and obtaining widespread recognition for providing value-added services in the community. Subsequently, this is established as a new system at the macro level. This “practice-before-policy” British model can be defined as “traction-driven type”.

The Japanese model was selected and deployed after observing other pioneering countries, including the USA and the UK. It is characterized by taking into account its own national conditions and not adopting a radical model of complete change overnight. Instead, it guides change by adding new content to the existing structure, which remains largely unchanged. Eventually, the original structure is gradually replaced through the continuous increase in the proportion of new content, thereby forming new functions. It is important to note that the development speed of the new content must be faster than that of the original content. This approach takes a longer time and

fully accommodates the existing foundation, thereby achieving a smooth transition. This method of “gradual addition and replacement” can be defined as the “grafting type”.

The choice of which model a country adopts for the development of clinical pharmacy primarily depends on its specific circumstances. On the one hand, it involves the maturity of social conditions and the difficulty of change; on the other hand, it involves the collaboration and rapid learning ability of professional teams such as medical organizations. The key takeaway here is that failing to follow established mechanisms can potentially create difficulties. Manifestations of macro-micro incoordination include the following:

First, the “disruptive type”: Regardless of all circumstances, making radical changes from macro to micro levels can cause overall discomfort and ultimately lead to failure.

Second, the “reverse-traction type”: This involves formulating macro-level rules first and then forcibly exerting pressure downward, forcing the grassroots level to make rapid adjustments, often resulting in superficial compliance and deep-seated resistance.

Third, the “insoluble type”: This occurs when new content is not carefully considered and is directly mixed with the old institutional framework. When the two entities lack compatibility, they can only coexist temporarily without achieving integration, ultimately leading to the failure of the reform.

In summary, from the sociological and management perspectives, we have essentially identified the origins for the commonalities in clinical pharmacy. Meanwhile, the differences in the macro-micro coordination process help us understand the reasons of the variations in its development models. The perspective of policy science facilitates

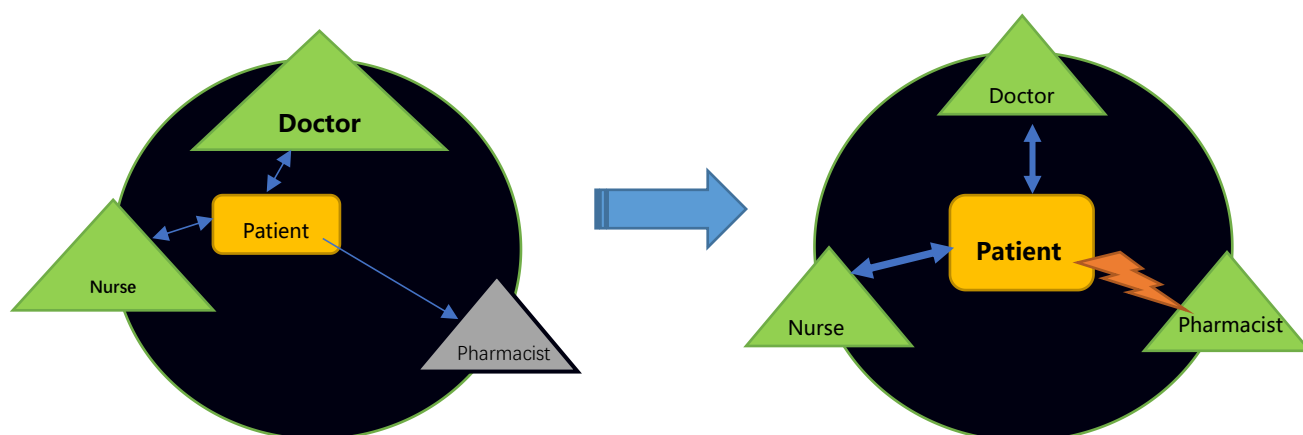


Figure 4 Organizational structure transformation driven by clinical medicine

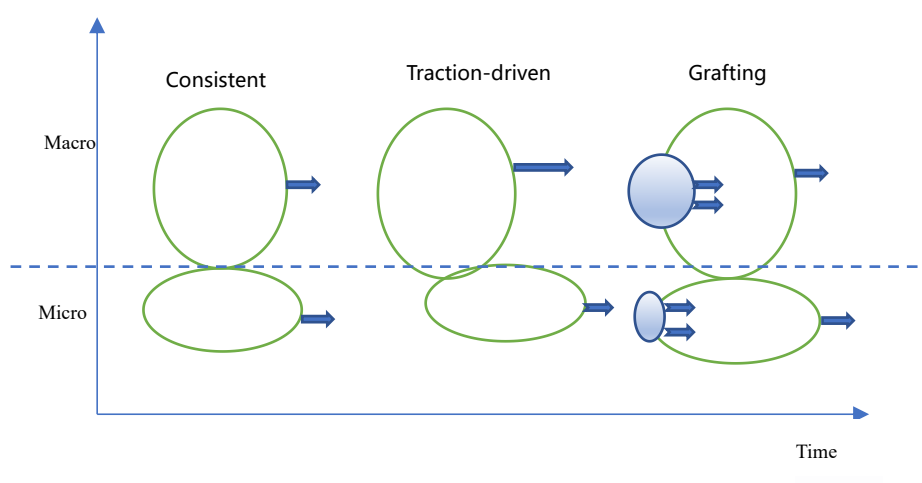


Figure 5 Three mechanisms for the successful development of clinical pharmacy

our understanding of the effects and both positive and negative aspects of the implementation of clinical pharmacy policies in different countries, providing a reference for later-developing countries to choose suitable catch-up paths. However, it struggles to elucidate the underlying logic of the implementation of different models. For instance, does the difference in a country's political party organizational structure influence the specific form of its policies? Must later-developing countries necessarily adopt different models from those of the first-movers? Or, conversely, must they draw commonalities from the first-movers while combining them with their own unique characteristics? If so, what is the basis for doing so? Therefore, the perspective of policy science is powerless when it comes to addressing the issues and guidelines in the specific process of implementing catch-up models.

Evaluation of multi-perspective research

It should be said that multi-perspective research has made certain progress in addressing the mechanisms of clinical pharmacy. From the sociological and management perspectives, we have actually identified the common causes underlying the emergence of clinical pharmacy. Meanwhile, the analysis of the macro-micro coordination process from the policy science perspective helps us understand the reasons for differences in its development routines and implementation effects.

By examining the development models of the pioneer countries, we can observe their respective emphases and strengths. Both the American and British models were initiated with a sociological foundation, emphasizing the core of deepening social care. In contrast, the Japanese model was initiated on the basis of management, as Japan was relatively later in this field compared to the UK and the USA. Through “high-degree collaboration” and “charging service fees”, clinical pharmacists could quickly integrate into society and exert their effectiveness. The UK and the USA did not deliberately emphasize a management perspective because both countries had well-established democratic habits and deeply ingrained traditions of contractual cooperation. Meanwhile, Japanese society has long held a devout commitment to the health of its citizens and a meticulous professional ethic for high-quality services. These are the reasons why these three models, despite having different initiating approaches, have all achieved relatively good results (Table 2).

It is worth mentioning that the American, British, and Japanese models have all made strides from a policy science perspective. Compared to sociological and management perspectives, the policy science perspective seems to be a “common denominator”. This has led to a trend where later-developing countries often forgo sociological and management perspectives and directly adopt the policy science perspective. However, it should be noted that this is precisely not the starting point of these three models. Consequently, later-developing countries often achieve less-than-satisfactory results in the implementation of clinical pharmacy. Discussing this further, it seems that the most promising strategy for success is to initiate clinical pharmacy when a country has a very high level of social services, willingness for management collaboration, and policy alignment. However, this limits the development potential of later-developing countries.

Theory of knowledge: a philosophical examination of clinical pharmacy

The first-tier research, which analyzes the three models of the US, the UK, and Japan, remains at the level of phenomenological generalization. The second-tier research, which incorporates multiple perspectives to reveal the causes and path choices of these models, still lacking in-depth examination of ontological nature. The viewpoint of this article is that the emergence of clinical pharmacy, in a sense, represents a transformation within the realm of knowledge. Specifically, it addresses the lack of pharmaceutical expertise among clinicians, the lack of knowledge about clinical patient responses among pharmacists, and the lack of understanding among patients

regarding medical advice and medication contraindications. Therefore, the cultivation of clinical pharmacists and the birth of clinical pharmacy are products aimed at bridging this “knowledge gap”. Tracing back the history of clinical pharmacy, we can find that as early as 1966, Brodie first defined drug-use management as a system integrating knowledge, understanding, judgment, management, and ethics [25]. Subsequent developments in clinical pharmacy, although not emphasizing this practical tradition, have always been closely linked to it. It is also from this perspective that the frontier of clinical pharmacy, which is drug innovation, can be better explained.

Therefore, discussions based on practical philosophy inherently align with the development trajectory of clinical pharmacy and possess valuable operational coherence [26]. This is precisely what is lacking in the aforementioned multi-perspective research, and contributes to the formation of an integrated model [27].

Sub-theory of three worlds

The discussion here focuses on the narrow sense of the theory of knowledge, which differs from Epistemology, a main branch of philosophy. Our primary research here concerns how to acquire the necessary knowledge in practical fields and what form this knowledge takes. Among various theories, Karl Popper's “Theory of Three Worlds” serves as the theoretical foundation for this section. Popper believes that besides the physical world (World 1) and the world of human emotions (World 2), there exists a world of theoretical systems (World 3), which is the world of objective knowledge. This article argues that the goal of clinical pharmacy and the cultivation of clinical pharmacists is to facilitate the internal coherence and balanced distribution of the knowledge world of World 3, while exerting its influence in World 1 and World 2, ultimately improving people's health status and development potential [28].

Essentially, all specific scientific knowledge is incomplete, which is the nature of science. However, it is undeniable that the truth itself, attempts to understand the truth, and reflections of the truth belong to three different worlds. If World 1 (the physical world) is causally closed to World 2 (the subjective knowledge world) and World 3 (the objective knowledge world), it would be of no benefit to us. Popper believes that what we do is strive to move from World 2 to World 3, continuously expanding the boundaries of World 3 while adhering to the “logic of discovery”, and in turn, acting on World 1 to improve human production and life.

Ultimately, the development appeal of clinical pharmacy and the enhancement of the integration between “clinical medicine (including nursing) and clinical pharmacy” represent a fusion of knowledge. The corresponding clinical pharmacist training systems, whether following the British-American model or adapted for late-developing countries, can be attributed to the core concept of “knowledge”. In other words, clinical pharmacy ultimately involves converging and refining various types of knowledge contained in different fields and individuals, and through further collision between theory and practice, generating more useful new knowledge to exert its effectiveness. Together, this aligns perfectly with Popper's definition of “World 3” [29].

Our hypothesis is that World 3 can be divided into two parts: A and B (Figure 6). All objectively acquired knowledge generated postnatally initially enters area A, but only axioms, publicly accepted propositions, and tested objective knowledge accumulate in area A. Knowledge with flaws, defects, or errors inevitably sinks into area B as human understanding deepens. The realization of this process is a repeated cognitive process. Area A follows the laws of causality and reproducibility; Area B does not follow the laws of causality but may exhibit chance occurrences. In terms of clinical pharmacy, any current pharmaceutical knowledge in 3B must rely on interactions with World 1 and World 2 to separate the true from the false and discard the coarse to retain the essential, in order to potentially ascend to the level of 3A knowledge. Only continuously expanding pharmaceutical knowledge that enters 3A can truly address the issue of “knowledge discontinuity”. Developing clinical pharmacy in later-developing countries should directly address the issue of transitioning from 3B to

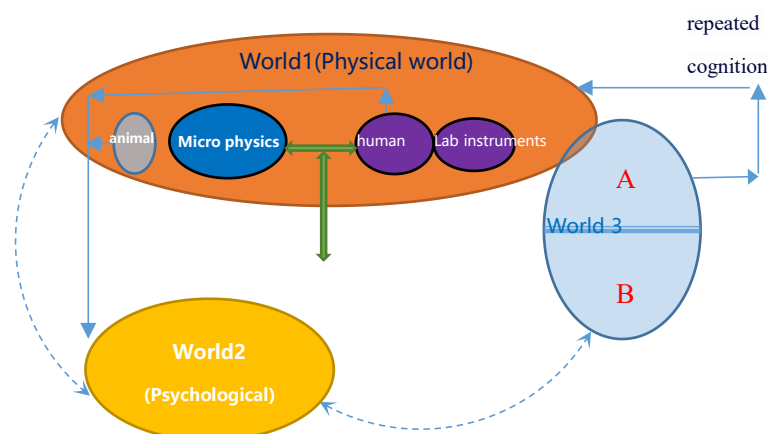


Figure 6 The relationship between Popper's three Worlds and clinical pharmacy research

Table 2 Comparison between different models under multi-perspective research

	Sociological perspective	Management perspective	Policy-science perspective	Evaluation
American model	Bio-psycho-social	—	Unique qualification with appropriate authorization	Natural development and adaptive support
British model	Community service – deepening	—	High-level authorization	Strong public welfare orientation
Japanese model	—	Highly synergistic Service fee charging	Unique qualification	Focus on the implementation of micro-level practices
Later-developing countries	—	—	Strengthen the education and allocation of clinical pharmacists	Lack of a foundation for social application

3A, rather than focusing on how to shoehorn advanced models into local contexts.

Sub-theory of expertise acquisition

If the theory of three worlds reveals the necessity and essence of expanding “World 3A knowledge” in general, then it is the theory of expertise acquisition that unveils the progressive nature of clinical pharmacist training on an individual level.

Clinical pharmacy also has a fundamental characteristic, which emphasizes the integration of “practice and theory”. Pharmacists are encouraged to move from the background to the clinical setting, working alongside doctors and nurses in hospital inpatient clinics, community clinics, and long-term home treatment, all of which can be attributed to the aspiration of “making good use of specialized knowledge”.

The Theory of Expertise Acquisition, or the Studies of Expertise and Experience, originated in 2002 when Harry Collins and Robert Evans proposed this research area in the development prospects of the “third wave of scientific research” [30]. Prior to this, the Dreyfus model, which outlines five stages of expert development (novice, advanced beginner, competent, proficient, and expert), had been the leading framework in this field. Unfortunately, while the Dreyfus model is more effective as a criterion for judgment, it falls short as a practical guide.

The theory of expertise acquisition posits that expertise nurtured by experience constitutes a special type of knowledge system. Its value lies in the role its possessors play in technical decision-making and ultimate technical applications, and it points out specific pathways to acquiring expertise. It encompasses three types of expertise: interactional expertise, contributory expertise, and referred expertise. In particular, interactional expertise deserves attention as it specializes in the specific language of a field rather than hands-on experience. In the professional practice of hands-on experts, understanding their discourse requires more interactional expertise

[31]. In technical decision-making, the lack of expertise hinders one's ability to understand and participate in technical discussions; interactional expertise enables the understanding and communication of technical content in decisions, and only it can combine various types of expertise. Contributory expertise refers to the relevant expertise that can directly contribute to technical decision-making. Referred expertise is the expertise that can apply contributory expertise from one field to another.

The theory of expertise proposes a hierarchical hypothesis for acquiring and developing expertise. The lowest level is the absence of expertise. The intermediate level includes interactional expertise and contributory expertise. The highest level, which is not clearly defined, should, according to our understanding, encompass referred expertise (this highest level may also include other more abstract types of expertise, which are currently not well understood, as illustrated in Figure 7). In clinical teams, the primary role of adding clinical pharmacists is to leverage their high-level contributory expertise (related to pharmacy and embodied in the tacit knowledge of pharmacists) through interactional expertise. Among them, as patients, by enhancing their own interactional expertise, they can cooperate with doctors and pharmacists in treatment and provide accurate and timely feedback on treatment. As doctors, nurses, and pharmacists, through their respective interactional expertise, they form an expertise ecosystem of contributory expertise, significantly enhancing the positive effects of treatment. The addition of clinical pharmacists increases the negative entropy of the entire ecosystem by strengthening their interactional expertise!

The issue here lies in the extreme importance of interactional expertise in the training of clinical pharmacists. It is generally believed that incorporating courses in psychology and sociology into theoretical learning, combined with long-term internship experiences, enables clinical pharmacists to acquire a considerable level of interactional expertise before officially practicing. However, in reality, within the ecosystem of “clinicians-nurses-clinical pharmacists”, there

exists a phenomenon of “expertise competition”. There are complex relationships between the clinical and pharmaceutical experiences of clinical pharmacists and the clinical, diagnostic, and nursing experiences of clinicians and nurses. When making final decisions, which type of expertise should be relied upon as the ultimate basis? In Western societies (such as the USA), there is a well-established and long-standing tradition of democratic decision-making. However, in some developing countries, a long-standing bureaucratic decision-making tradition gives clinicians (usually doctors, other than pharmacists) greater authority. Therefore, when clinical pharmacists enter the work environment, they must resolve the relationship between “expertise competition” and “expertise collaboration” with the help of bureaucratic leaders, forming an interactional expertise in a specific context to bridge the gap in the P-phase (Figure 8).

Feasibility analysis from the perspective of knowledge

The adoption of a knowledge perspective not only brings clarity to the innate explanation of the developmental trajectory of pharmacy, generalizing the evolutionary history of pharmacy from “risk-based medication use” to “rational drug use” and then to “precision medicine” as a process of “knowledge deepening”, and sharply pointing out the significance and value of clinical pharmacy. More importantly, multiple existing research perspectives can be specifically integrated with the knowledge perspective (Figure 9).

From the perspective of implementation scope, the macro perspective of knowledge corresponds to policy studies. Supported by the theory of three worlds, the macro perspective of knowledge views

the expansion of the human medical knowledge base from a holistic angle. For policy studies, the formulation and implementation of policies related to clinical pharmacy are invariably aimed at achieving corresponding effects by imitating key systems of pioneering countries and bridging relevant gaps. These expectations ultimately manifest as the enrichment and completeness of knowledge in this field.

From the perspective of implementation scope, the micro perspective of knowledge corresponds to management studies. Supported by the theory of expertise, the micro perspective of knowledge views the functions of clinical pharmacists from a microsystem angle. For management studies, the main focus is on the expansion of micro-teams and role embedding. The criteria for assessing these issues are not, and should not be, the degree of interpersonal harmony within the team, but whether the “professional expertise” of clinical pharmacists is respected and effectively utilized.

From the perspective of implementation targets, the comprehensive perspective of knowledge corresponds to sociology, complementing the deficiencies of current sociological research. From a sociological perspective, clinical pharmacy primarily focuses on the transition from “medication” to “human”. From an epistemological standpoint, this represents a macro-level shift in the focus of pharmaceutical knowledge development from “the development of common drugs” to the “uniqueness of patients’ comprehensive syndromes”. “Medication + human” constitutes a “knowledge object” beyond the medical team. What sociology generally ignores is the transformation of pharmacists’ identities from general licensed pharmacists to clinical pharmacists. From the knowledge perspective, this represents a micro-level internal



Figure 7 Three levels of expertise

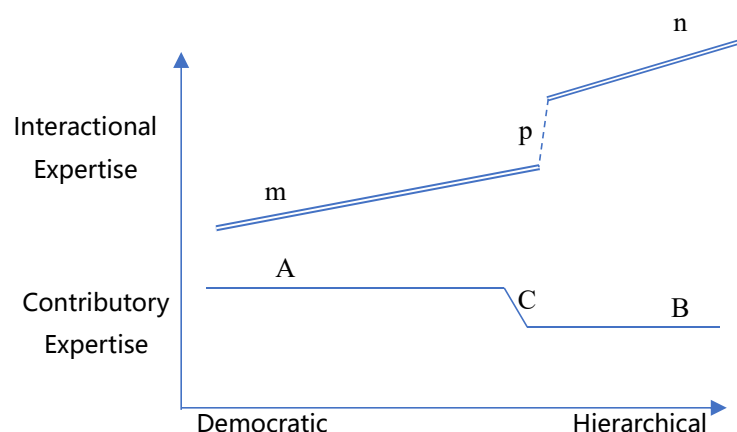


Figure 8 Cultural tradition and the exercise of expertise characteristics

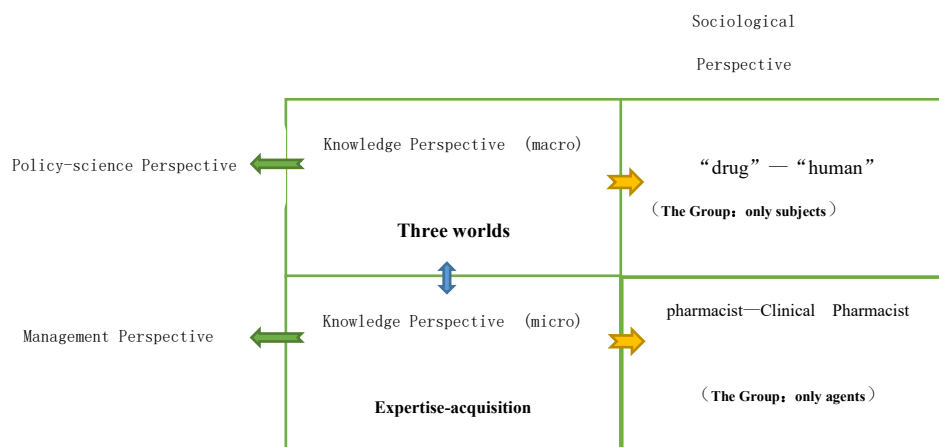


Figure 9 Knowledge perspective's integrative role in a philosophical way

decision-making integration of all medical personnel, excluding patients, as “knowledge providers and implementers”. The observation of these two different “others” constitutes the complete vision of the sociological perspective. This is precisely the inspiration and supplement obtained from the knowledge perspective, which is undoubtedly meaningful.

Thus, the knowledge perspective not only reflects the achievements and propositions of existing multidimensional research (policy studies, management studies, and sociology), compensating for overlooked aspects, but also incisively clarifies the cores of these three perspectives.

The harmonious interaction between the macro and micro levels of knowledge can address the difficulties in dialogue and coordination among “policy studies, management studies, and sociology” through a single, simple mechanism. Specifically, the triple interaction mechanisms of “policy studies-sociology”, “management studies-sociology”, and “policy studies-management studies” are replaced by a single interaction mechanism of “macro-epistemology-micro-epistemology”. Theoretically, this provides a high degree of feasibility and controllability for late-developing countries to establish their unique clinical pharmacy systems based on their different social, economic, and political conditions.

The current situation, challenges, and countermeasures for the development of clinical pharmacy in China

Current situation and challenges in China

The development of clinical pharmacy in China, including the mainland, Hong Kong, Macao, and Taiwan, progresses in different ways and at different paces.

In Hong Kong, it synchronizes with the British and American regions. In the 1990s, the Hong Kong Hospital Authority required pharmacists to transition towards clinical roles. Taking Queen Mary Hospital in Hong Kong as an example, it began offering drug information services and clinical oncology research in 1995. Currently, it has 36 clinical pharmacists who can provide round-the-clock, safe, high-quality, patient-centered, and comprehensive clinical pharmacy services. The pharmacist training system is similar to that of the UK and draws on practices from the USA. For instance, the Faculty of Medicine at The Chinese University of Hong Kong established the Department of Pharmacy in 1992. After completing a (4 + 1) curriculum and clinical internship, students can register as pharmacists. The University of Hong Kong also offers a two-year Master of Clinical Pharmacy program, while the curriculum system at The Chinese University of Hong Kong draws on North American doctoral programs to cultivate high-level clinical pharmacists.

Relatively speaking, Taiwan established the Society of Clinical Pharmacy in 1987, but it was only after 1997 that intensive care unit services and an adverse drug reaction reporting system were included in hospital evaluations. In 2007, Taiwan amended the “*Pharmacist Act*”, officially ushering in a new era of pharmacist care. Besides pharmaceutical service fees, “pharmacist care fees” were introduced, extending to the community level. Clinical pharmacy education primarily adopts the Pharm.D. training model from the USA. Additionally, National Cheng Kung University, National Taiwan University, and Kaohsiung Medical University all offer master's degree programs in clinical specialties. Individuals who complete a six-year Pharm.D. program and earn a master's degree in clinical pharmacy can apply for doctoral programs to become high-level clinical pharmacists.

On the mainland, after the founding of the People's Republic of China, Chinese hospital pharmacy went through three stages: “finding drugs”, “purchasing drugs”, and “administering drugs”, before undergoing a renaissance in the 1990s. Just after overcoming the dilemma of drug scarcity and possessing considerable drug supply capabilities through both domestic production and imports, the academic community actively advocated for clinical pharmacy work, which was quickly put on the agenda under the leadership of the Ministry of Health. In 1991, the Ministry of Health stipulated in the document on graded management of hospitals that tertiary hospitals must carry out clinical pharmacy work, which was also included as one of the assessment criteria. In 1999, the Ministry of Health issued the “*Outline for Standardized Training of Hospital Pharmacists*” (trial), stipulating that clinical internships such as ward rounds, consultations, and drug treatment must be conducted in the final year of the two-phase, five-year training program. In January 2002, the Ministry of Health and the State Administration of TCM jointly issued the “*Interim Provisions on the Administration of Pharmacists in Medical Institutions*”, legally establishing a “patient-centered” pharmaceutical work system. In 2007 and 2013, two batches of key specialty construction units for clinical pharmacy were approved, with a total of 17 hospitals, including Peking University and Peking Union Medical College Hospital, selected. In 2014, the Teaching Steering Committee of Pharmaceutical Sciences in Institutions of Higher Learning under the Ministry of Education (Pharmaceutical Steering Committee) drafted and approved the “*National Standards for the Teaching Quality of the Clinical Pharmacy Undergraduate Program*” and the “*Standards for the Practice Teaching Base of the Clinical Pharmacy Program*”, clearly stipulating the teacher qualifications, curriculum system, teaching support, and practice base standards for the clinical pharmacy program from a systemic perspective. These are the results summarized and consolidated based on multiple explorations and practices by West China Hospital (1987), Peking University (2001), the Five Universities Alliance in North and South China (2003), Fudan

(2009), and others in the educational sector. In 2015, the Chinese Hospital Association revised and issued the “*Outline for Professional Training of Clinical Pharmacists*” (2015 Edition), incorporating one general and 14 professional training outlines. Over 220 clinical pharmacist training bases have been established, with 17 selected as teacher training bases, training over 500 teachers annually. However, there are also obvious problems, mainly including: it is difficult to cultivate high-quality clinical pharmacists, with a lagging teaching staff and textbooks; there are issues of unclear responsibilities and poor coordination between clinical pharmacy personnel and clinicians; paradoxes exist in the allocation of specific energy for research and clinical ward rounds; pharmacist service fees are difficult to implement for various reasons, and so on. The enthusiasm and ability of clinical pharmacists, and even how to continuously improve their clinical skills, have encountered practical obstacles and bottlenecks [32].

Currently, China primarily focuses on the perspective of education as a means to overcome these difficulties, meaning that emphasis is placed on the cultivation of clinical pharmacists, especially increasing their amount. However, the key to clinical pharmacist training cannot solely focus on the education system itself. In particular, there is insufficient estimation of the long-term nature, holism, and adaptability of clinical pharmacy education. Even if the Pharm.D. model is comprehensively adopted, the current issues will not be resolved instantly. This is a path that requires long-term collisions, adjustments, and creative development.

Since the reform and opening-up, while China’s economy has achieved tremendous breakthroughs, the quantity and quality of China’s clinical pharmacist team have not kept pace with the development of a major socialist country. China also has a notable characteristic of regional imbalance. The principal contradiction facing Chinese society today – inadequacy and imbalance – is also evident in the clinical pharmacy system. Between coastal cities and inland cities (central and western regions), between core areas and outer suburbs of large cities, and between public hospitals and private hospitals in large cities, these are precisely the areas where clinical pharmacy services are difficult to deepen, most lacking, and most urgently needed [33–36]. It is also reflected in the sustainable requirements of China’s unique medical system. In particular, clinical pharmacy services for TCM have their own uniqueness. TCM pharmacists are generally distributed across various levels, including TCM hospitals, comprehensive public hospitals, and community clinics. The cultivation of TCM pharmacists and their clinical uniqueness, as well as the complexity of simultaneous and long-term cross-medication of TCM and Western medicine for patients (especially special populations such as the elderly), make the implementation and integration of clinical pharmacy services a major challenge [37–39]. Currently, explorations in various aspects such as optimizing prescription processes and clinical coordination are the prelude to the many efforts required to tackle this tough issue [40–44].

The underlying reason is the exclusive focus on the perspective of policy studies, while neglecting the perspectives of management studies and sociology. This approach, which attempts to swiftly

achieve ambitious goals by forcibly implementing a “clinical pharmacist” matching system, is destined to end hastily. The completion of apparent policy indicators disregards the actual domestic environment in China, even erasing some potential advantages, wasting considerable manpower and material resources, and delaying precious development time.

Strategies for the development of clinical pharmacy in China

On July 18, 2024, the 20th Central Committee of the Communist Party of China passed the “*Decision of the CPC Central Committee on Further Deepening Reform in an All-around Way and Advancing Chinese-Style Modernization*”, once again clarifying the guiding principle of “adhering to facing the frontiers of world science and technology, the main battlefield of the economy, major national needs, and people’s lives and health; optimizing the organization mechanism for major scientific and technological innovations; comprehensively strengthening research on key core technologies; and promoting the systematization, institutionalization, and synergies of scientific and technological innovation forces, factor allocation, and talent team”. Therefore, clinical pharmacy should be positioned within the entire system of new medicine, emerging as a new interdisciplinary field and linking a benign interactive mechanism with the social environment to radiate its due vitality and vigor.

Therefore, to develop clinical pharmacy in China today, it is necessary to shift from the past approach of imitating from the side to establishing a new framework for construction as a whole [45]. In other words, we should integrate the development of new technologies (especially new technologies for knowledge management) with the implementation of new clinical pharmacy systems simultaneously from an epistemological perspective (Table 3).

In this process, two paradoxes need to be addressed. The first paradox is that, despite China’s weak foundation, it cannot improve incrementally from a lower base; instead, it must keep pace with the latest technology and directly connect with the highest level, continuously increasing the volume of objective knowledge in clinical pharmacy, which is the direction of evolution. The second paradox is that, in implementation, it cannot start from tertiary hospitals in larger cities with better conditions; rather, it should begin at the grassroots level of community medical institutions and penetrate upwards from low to high. The advices are as follows.

Leverage artificial intelligence to develop a “World 3” clinical pharmacy intelligent platform. From the perspective of “World 3”, a nationwide clinical pharmacy AI platform should be established in China. This platform will organize the “objective knowledge” tested through daily practice by hospitals, clinics, doctors, clinical pharmacists, and nursing staff. Meanwhile, occasional cases, both successful and failed, should be entered into the system based on facts.

Furthermore, the AI provides access control. The system first opens input functionality to registered medical staff and scientific researchers, but only grants patients the right to ask questions and consult. Within a certain scope, it can be opened to foreign professionals. Patients can input their personal physical indicators as basic data. Additionally, both TCM and Western medicine can be cross-integrated.

Table 3 Different strategic combinations for clinical pharmacy deployment

	Initial institution – high	Initial institution – low
Initial technology – high	The self-owned funds are adequate, allowing for the quicker adoption of the latest technologies. However, there are significant internal obstacles within the institutional team.	The application of technology can proceed quickly without institutional resistance. However, it requires substantial external funding.
Initial technology – low	It is easy to implement, but the effect is not significant. There will be long-term delays, ultimately leading to low evaluations of clinical pharmacy from all parties.	The effect is not significant. Patients ultimately flow back to large or super institutions, even though the role of clinicians in the latter is also not prominent.

Moreover, it primarily provides patients with medication reminders in text, video, and portable alert formats, and assists clinical pharmacists and clinicians at various levels in making treatment recommendations. It also offers a computer simulation system to precisely estimate pharmacological effects and refine them. It can be used anywhere with an internet connection.

The establishment of this platform focuses on expanding “World 3” knowledge and providing timely services to more people by eliminating falsehoods and retaining truths. The training period for clinical pharmacists can be shortened and, to some extent, replaced. Since such a large-scale platform has not been established, much knowledge accumulated by high-level doctors and pharmacists may disappear with their lifetimes, but this phenomenon can be curbed. This long-standing and upgraded AI platform will become a common wealth of mankind.

Specific implementation paths include: first, encouraging commercial companies to emerge in various segments, ultimately forming a huge, shared, and comprehensive master platform through technological alliances. Second, each country should establish its own laws to protect data from malicious use, ultimately contributing to the highest binding force of global international law. Although it seems difficult at present, in fact, emerging companies have already begun valuable attempts in the first aspect; urgently, governments need to keep pace with the times in legal supervision and protection and make a difference.

Empower and shape round-the-clock clinical pharmacists based on primary healthcare institutions. China has a large population, but medical consultations are concentrated in tertiary and secondary hospitals. Expanding the scope and quality of primary healthcare services is imperative. Implementing high-quality clinical pharmacy services in primary healthcare institutions, including community pharmacies, clinics, and small general hospitals, has various advantages and potential.

First, for most common diseases, clinical pharmacists can directly issue prescriptions and provide corresponding medications after training. For example, general respiratory diseases, digestive diseases, common chronic conditions, and common emergency medications. For severe and complex diseases, after initial diagnosis by primary clinical pharmacists, timely and accurate contact and assistance can be provided for transfer to large hospitals for treatment.

Second, primary clinical pharmacists can flexibly use internet platforms for remote consultations, enabling multiple related experts to jointly diagnose patients online. Combined with modern logistics networks such as unmanned supermarkets and drones, costs can be reduced and efficiency increased. The implementation of these new services is easier in small primary institutions.

Finally, although primary healthcare structures prioritize the deployment of clinical pharmacists with small scales and multiple locations, they are not difficult for regulatory authorities to oversee due to the integration of digital technology. For the public, it practically addresses the time-consuming and laborious current situation of difficulty in registering and seeing a doctor. Corresponding laws and regulations are needed to encourage and protect these reforms.

From the perspective of expertise acquisition theory, interactional expertise serves as an intermediate media language for special interactions among different groups. There is tension between informal/tacit knowledge and formal/propositional knowledge, and interactional expertise resolves this tension by communicating with experts who possess contributory expertise. In other words, interactional expertise is understanding ability. In primary healthcare institutions, with clinical pharmacists taking the lead, the tension between “(clinicians + nurses) vs. clinical pharmacists” in large medical institutions is dissolved, greatly reducing the difficulty and cost of developing interactional expertise. Since primary clinical pharmacists are stationed among patients for a long time, communication between patients and clinical pharmacists is more sufficient, which is more convenient and efficient than patients entering large medical institutions and having passive communication

with the specialized team of “doctors + nurses + pharmacists” for a few minutes to more than ten minutes.

After long-term training in primary healthcare institutions, clinical pharmacists with good work performance and a certain degree of authority are more likely to be respected and better integrated when upgraded to large medical institutions, thereby effectively utilizing their contributory expertise. The pharmacist system can be suggested to be divided into three levels: trainee pharmacists, licensed pharmacists, and clinical licensed pharmacists. The last level requires a minimum of five years of practice and an age of over 35, with significantly increased income and salary.

Interact between personal expertise and integrated platforms. In the future, pharmacists will serve as comprehensive service providers for end-users, patients. With the assistance of ward-patrol robots and home healthcare robots, and after rigorous verification of medication feedback, more precise frontline research results can be obtained. These results, after secondary verification, can be shared on a more scientifically robust integrated knowledge platform in real-time. This represents an upload process, which can also be reversed.

Through repeated reversals and cycles, clinical pharmacists and the comprehensive AI healthcare system form a tightly integrated organism, thereby truly achieving “precision medicine”. In response to patient’ needs, a phenomenon similar to ride-hailing apps like Didi Taxi or Uber will emerge, where multiple doctors compete online to accept cases. In daily care, due to the widespread adoption of wearable devices, ordinary people can receive more prompts and practical help for regulating “sub-health” conditions, preventing diseases before they occur. In this regard, TCM knowledge will play an increasingly significant role.

From a broader perspective, future clinical pharmacy will not only integrate with AI technology but also with various other fields of knowledge such as biology, chemistry, physics, geography, and climatology, etc. This provides infinite possibilities for drug innovation.

Conclusion

Starting with an analysis of the distinct characteristics and common features of clinical pharmacy development in advanced countries, this article summarizes three models: the American, British, and Japanese models. It uncovers that the intricate phenomena behind these developments are the result of multifaceted competitions rooted in sociology, management science, and policy studies. Through a philosophical examination of clinical pharmacy, this article takes the theory of knowledge as a new theoretical foundation. And the sub-theory of three worlds and the sub-theory of expertise acquisition are adopted to reveal the evolutionary essence of clinical pharmacy from both a general and an individual perspective. Based on this foundation, corresponding high-quality development strategies for the advancement of clinical pharmacy in China are proposed, advocating for a basic development route centered on “high-tech facilities – low-tier institutions”.

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