Quality of primary health care in China

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Quality of Primary Health Care in China: Challenges and Recommendations

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Quality of Primary Health Care in China: Challenges and Recommendations

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Executive Summary

As part of its health care reform in the past decade, China has significantly increased financial investment and introduced favourable policies for primary health care. However, widespread gaps in the quality still exist, which has contributed to missed opportunities to promote population health. In this review, we aim to identify the causes for poor quality, and provide policy recommendations for improvement. These gaps include suboptimal screening, diagnosis, and treatment of diseases, which compromise health outcomes. System challenges include: suboptimal education and training of primary health care practitioners; a fee-for-service payment system that incentivizes testing and treatments over prevention; fragmentation of clinical care and public health service; insufficient continuity of care throughout the entire health care system. Now is an opportune time for China to strengthen the quality of its primary health care as the government is shifting its reform attention to 'improving quality and enhancing efficiency (*ti zhi zeng xiao*, 提质增效)'. The following recommendations merit consideration: enhancement of the quality of training for primary health care physicians and tailor continuing professional development for the current workforce; establishment of performance accountability to incentivize high-quality and high-value care; integration of clinical care with the basic public health services; and strengthening of the coordination between primary health care institutions and hospitals. Additionally, China should consider modernizing its PHC system through the establishment of a learning health system built on digital data and innovative technologies that can combine tools for accountability, efficiency, and improvement. Lessons from these strategies could serve as a model to other countries facing similar challenges.

Introduction

As part of China's health care reform effort to provide its citizens with universal and equitable access to high-quality healthcare, primary health care (PHC) has received considerable attention (appendix A).[1] This focus is in recognition that the current hospital-centric delivery system is costly and does not serve the changing needs of its ageing population undergoing an epidemiologic transition.[2] China has introduced a number of policies to build PHC-based integrated delivery, and the government has increased its funding to these institutions by more than tenfold, from 19 billion yuan in 2008 to 197 billion yuan in 2018.[3-5] The role of PHC is further reinforced by the Healthy China 2030 Plan announced in 2016,[6] which introduces new directives for health development through prioritizing prevention and primary care.

The effectiveness of these directives hinge on whether China can build a strong PHC system with good quality of care.[7] Despite significant financial investment and infrastructure building (appendix B) in the past decade, however, there is evidence that the quality of PHC in China is still suboptimal, which also contributes to missed opportunities to promote population health and to improve efficiency of service delivery.[5,8]

In this review, we summarize the evidence on quality of PHC in China, analyse the causes for poor quality of care and provide policy recommendations for improvement. We adopt the European Primary Care Monitoring System (EPCMS) assessment framework to guide our analyses (panel 2).[9,10] This framework conceptualizes that both structural and process dimensions of a PHC system contribute to three outcomes for PHC: quality, efficiency, and equity. This review focuses on quality because it is essential for improving health outcome and gaining people's trust. We base our analyses on a literature review (panel 3) and original data collection through the National Primary Health Care Survey (NPHCS).[11] To develop policy recommendations, we also conducted interviews with key stakeholders, front line health workers, and policymakers, as well as evaluations of national and international examples.

Current Quality of China's Primary Health Care

In China, PHC institutions' functions include providing generalist care and implementing the National Basic Public Health Services Program (appendix D).[5] The EPCMS framework specifies nine measures for quality of PHC. In this review, we focus on quality of diagnosis and treatment, prescribing behaviour, and quality of chronic disease management, given the rising burden of non-communicable diseases (NCDs) in China and the priorities of its overall health care reform for establishing gatekeeping function of PHC. With respect to other measures covered by the EPCMS, China has already achieved maternal and child health outcomes that approach those of advanced economies,[12] and universal neonatal vaccination was estimated to have prevented 30 million chronic Hepatitis B viral carriers.[13] Unfortunately evidence on quality of mental health care and health promotion in PHC system is not generally available.

Quality of diagnosis and treatment

The quality of the diagnostic process and outcomes was low among PHC providers. A study using incognito standardised patients with common illnesses (dysentery and angina) in the western region showed that village doctors asked patients 18% of the recommended questions and performed 15% of the recommended exams. Doctors addressed 36% of the essential questions or examinations necessary for a proper diagnosis and to protect patients from harm, and correctly diagnosed 26% of the illnesses of these incognito standardised patients.[14]

In another study using incognito standardized patient with classic pulmonary tuberculosis symptoms, correct management proportions at township health centres (38%) and village clinics (28%) were significantly lower than at county hospitals (90%).[15] There is a significant variation of observed doctors' behaviour within each group (township health centres or village clinics) as well,[15] which was similar in other middle-income countries.[16]

Prescribing behaviour

Overuse of antibiotics is common in PHC institutions.[17-19] Systematic reviews showed that the overall weighted average proportion of antibiotic use was over 50% in PHC institutions,[20] much higher than the standard recommended by WHO (<30%).[21] A 2011 study based on a random sample of PHC institutions in 6 provinces of China also revealed that a quarter of outpatient antibiotics prescriptions and 68% of inpatient antibiotics prescriptions were inappropriate, and improper remuneration incentives was considered a key driver for these prescribing behavior.[22] Moreover, there was a preference of PHC doctors to use broad-spectrum antibiotics,[23] which is deemed quality issue related to professional incompetence,[24] and could induce the emergence and spread of drug-resistant strains of microbes.[24]

Non-communicable diseases like hypertension are largely undertreated. The largest hypertension survey in China, the NPHCS, found that one third of patients with confirmed hypertension diagnosis took no antihypertensive medication, and 42% took only one medication and their blood pressure were uncontrolled.[25] Meanwhile, it found that approximately 8% of medications used were not guideline-recommended,[26] while high-cost medications were more preferentially used than their counterparts that were evidence-based and cheaper.[26-28] These results suggest that in addition to medication supply defect, physicians' knowledge of and willingness to adhere to new hypertension treatment guidelines are issues that need to be addressed.[29]

Chronic disease management

With respect to hypertension and diabetes, the most common chronic conditions encountered in PHC settings (appendix E),[5] there is evidence of shortfalls. For hypertension, based on two recent nationally representative studies,[30,31] the poor awareness (32% and 47%) and control rates (10% and 15%) indicated gaps in both public health service (i.e. population screening) and clinical care (i.e. patient treatments), as well as poor integration between them in PHC institutions. Under-performance of PHC may explain China's much higher hypertension hospital admission rate (490 per 100 000 population) compared with all OECD

countries (average at 95 per 100 000 population).[32,33] Moreover, the poor performance in management of hypertension are estimated to lead to compromised health outcomes and tremendous economic losses (panel 4).

For diabetes, a nationally representative survey in 2013 of 170,287 Chinese participants found that only 37% of those with diabetes were aware of their diagnosis, and just 32% were being treated.[34] Another nationwide longitudinal survey from 2011 to 2015 identified a decrease in health education coverage (from 76% to 70%) and persisted gaps in use of examinations and treatments (from 79% to 81%), accompanied by an increase in both diabetes-related hospital admission (from 4% to 6%) and readmission (from 19 to 28%).[35] China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).[32]

Challenges in Structure and Process of Primary Health Care System

Using the EPCMS framework and drawing on existing literature and expert analyses, we identified two structural (workforce development and remuneration system and income of PHC providers) and two process (coordination of care and continuity of care) dimensions of China's PHC system as core contributors for gaps in quality of PHC.

Workforce development

The levels of education and qualification among PHC professionals are low. In 2018, 25% of PHC doctors in community health centres and 42% of township health centres had less than junior medical college level of education (the requirement for a licensed assistant physician), which does represent an improvement as the proportions have decreased from 41% and 60% respectively in 2010.[36] Since the nationwide reform of graduate medical education was issued in 2011[37], training for general practitioners (GP), including specific medical school education and in-service training, has been prioritized nationally. The number of qualified GP in China has doubled (from 100 000 to 300 000).[4,38] However, these qualified GPs constituted only a small proportion (from 4% to 13%) of all doctors practicing in China's

PHC settings. Moreover, due to a lack of qualified physicians, more than 20% of doctors practicing in community health centres, township health centres, and community health stations were not licensed (appendix H).[5,39] The lack of diverse multidisciplinary primary health care team persisted, as the doctor-nurse ratio is 2.6 compared to 1.5 in the UK,[4] which limits a functional response to the needs of the community.[40]

Substantial gaps exist in the in-service training of PHC professionals. PHC professionals in China are required to attend and earn a specific number of credits in the Continuing Medical Education programmes annually.[41] However, the NPHCS reported that more than a third of physicians, nurses, and public health professionals in PHC institutions received no Continuing Medical Education in 2016.[5] PHC professionals complained that they were too busy to attend trainings, and the trainings failed to meet their needs due to poor contents and unqualified trainers.[42] Furthermore, while there is a plethora of guidelines and consensus statements issued by various academic and professional bodies (e.g. in hypertension there are at least five clinical guidelines and thirteen consensus documents from 14 bodies), the lack of one authoritative, national guidance for each common condition has been an issue in the presence of a relatively poorly trained workforce.

Remuneration system and income of primary health care providers

Traditionally, PHC providers (and all other health care providers) in China have been reimbursed via the fee-for-service payment system according to a fee schedule set by the government, whether paid by social health insurance or patients' direct out-of-pocket payment. This fee schedule pays diagnostic tests above cost and labour-intensive services (such as consultation) below cost. Providers were also allowed to charge a 15% mark-up for prescription drugs. This payment system created financial incentives for testing and prescription writing, irrespective of clinical necessity.[18] Meanwhile, there are few incentives to improve quality of care. The NPHCS found that payments for PHC physicians do not reward quality and the bonuses for PHC physicians that constitute 30% of their income were most often determined by the quantity, rather than the quality of care delivered.[5]

In 2011, the Government introduced the zero-drug mark-up policy, with the aim of removing providers' incentives to over-prescribe. The removal of drug mark-up was designed to be coupled with a fee schedule adjustment – increasing fees for more labor-intensive services and reducing fees for diagnostic tests – to compensate providers for lost revenue from drugs and to reduce incentives for diagnostic tests. Local governments were expected to increase fiscal subsidies to providers as well. However, largely because of fragmented governance, simultaneous implementation of these polices has proven difficult and evaluation studies find that removal of drug mark-up has had mixed effects on reducing the inappropriate use of drugs, especially antibiotic use.[7] Also, removal of drug mark-up has severely affected the revenue of PHC institutions, where more than 50% of the revenue typically comes from drug sales and the provider bonuses depend on drug revenues.[43] Community and township health centres saw a roughly 40% decrease in drug-related incomes since 2011 due to the removal of drug mark-ups.[44,45] As a result, some PHC institutions apparently made up for their revenue loss by using more intravenous treatment and diagnostic tests, and shifting outpatient care to inpatient care,[53,59] whereas others seek to minimise the amount of clinical care they perform given that there is limited net revenue to be earned. Their lack of willingness to provide clinical care have contributed in some ways to increase in patients presenting at hospitals with minor ailments.[46,47]

Coordination of care

In China, usually PHC providers are not the point of first contact, nor do they coordinate with specialty care. PHC institutions in China provided 53% (4·4 billion) of outpatient care in 2018, which had been declining notably from 62% in 2010,[4,48] despite efforts to strengthen the PHC system in the 2009 health care reform. In a survey covering 17 provinces, the most common reasons that patients bypassed PHC institutions as they need clinical care was poor capacity and skills of the professionals (32%).[49] In a 2013 study, 26% of patients responded that they distrusted community health centres, compared with 6% for hospitals, moreover, patients who knew or have seen doctors at community health centres were more likely to have

a negative view of, and an unwillingness to use community health centres.[50] Moreover, as residents of the local community don't seek care at PHC institutions, the ability for PHC institutions to perform public health functions under the National Basic Public Health Service Program could be substantially compromised.

In 2015, the Chinese government issued guidelines for building a "tiered healthcare delivery" system whereby each level of health care facility (tertiary, secondary and primary) would deliver care according to their designated functions,[51] and care across the levels were to be integrated and coordinated with bidirectional referral mechanisms through establishing medical alliance or integrated systems.[52] In spite of some successful pilot experiences in local areas like Shanghai, Shenzhen (Guangdong) and Tianchang (Anhui),[53-55] scaling up of these pilots have been slow and hindered by several factors. First, as hospitals and PHC institutions are still primarily paid by fee-for-service, they compete for patients and have little incentives to coordinate. Second, the social health insurance program, which covers 96% of the population,[4] reimburse patients wherever they seek care without referral, so there is generally no defined coordinating process. In addition, reimbursement for hospital care is more generous than for care at PHC institutions thus incentivising patients to bypass PHC facility, making it difficult for PHC providers to play the gatekeeping function. Third, electronic patient records are not integrated and are seldom shared between PHC institutions and hospitals.[56] Therefore, even though partnerships between hospitals and PHC institutions are encouraged and have formed in many cities,[57] the association is thus far a loose one.

Within PHC institutions, the National Basic Public Health Service Program could provide a basis for integration between clinical care and public health services. However, the reality was suboptimal for two reasons. First, financing for public health services and clinical care of the same PHC institutions came from different sources. While the government directly funds a defined package of public health services, clinical care is funded by social health insurance. Second, there is almost no coordination in monitoring, performance measurement, or management between the two programs. Thus, as we observed as both researchers and

practitioners, there is little workflow interaction or information sharing between the two. For instance, in hypertension management visits under the National Basic Public Health Service Program, patients can have blood pressure measurement and lifestyle consultations by public health workers, but cannot get antihypertensive prescriptions without attending the clinics. Also, resident health records on public health services and medical records on clinical care are kept by two separate information systems even for the same visit of the same patient and there is no linkage between them. The poor care coordination is a hindrance particularly to managing NCDs. Similarly for infectious diseases like tuberculosis, complete socio-demographic and clinical information on individuals with presumptive tuberculosis cannot be linked across the Infectious Disease Reporting System and the Tuberculosis Information Management System due to the different identification numbers, even both of which were developed by the China Centers for Disease Control and Prevention (CDC), thus analysis on characteristics of individuals who did not complete the referral are not feasible.[58] Finally, since many patients do not seek first contact care (e.g. for acute self-limiting conditions) from PHC institutions, this severely limits the opportunity of integrating clinical care and public health services.

Continuity of care

PHC providers are in a central position to coordinate a person's care needs, from prevention, disease management to curative care. There are several barriers to overcome before this aspiration becomes a reality. The concept of continuity of care entails several dimensions. First, 'relational continuity' encourages patients to enter into contractual arrangements with family doctors. However, China does not make it compulsory for patients to see PHC providers as their first contact. As the first step towards building a gatekeeping system, the government has introduced a family doctor registration policy by which each resident would be registered with a team of family doctor,[59] however, it is still in an early stage and its potential has yet to be realised. Moreover, there is a general lack of patient

awareness about the importance of continuity of care. In a study in Beijing, patients' strong preference for free choice between general practitioners and specialists was not aligned with relational continuity with PHC.[60]

Second, there is inadequate 'informational continuity' throughout the system. The electronic medical record system in PHC institutions is still commonly unavailable, fragmented, and isolated in its ability to integrate and analyse comprehensive information about individual patients.[5] The establishment of the centralised resident health record system in the National Basic Public Health Service Program for the entire catchment populations potentially places PHC services in a position to take a cradle-to-grave approach to managing health care. However, the potential to use these data goes unfulfilled.

Third, with respect to 'managerial continuity', because PHC institutions and hospitals are financed, governed, and managed separately,[61] there are barriers to ensuring consistency, coordination, and quality of care across sites of care. Thus, there are few opportunities for different health care providers to maximise effectiveness of the joint efforts and minimise wastage from redundant actions and interventions.

Recommendations for Improvement

To improve the quality of PHC in China, we propose recommendations for addressing the structural and process weaknesses in the system. Overtime, China could modernize its PHC system through the establishment of a learning platform for evidence generation and training, as well as performance monitoring and promoting.[62] These recommendations could guide China's action plans in terms of policy formulation and designing pilots to test the recommendations' effects and feasibility.

Enhance the quality of training for new and current primary health care workforce

The State Council issued the guidance on reform and development of training and incentive mechanisms for PHC physicians (appendix I).[63] Despite this, a comprehensive range

of detailed recommendations on the quality of training are needed to address the wide variation in standards of medical school education. First, the Ministry of Education should consider working closely with the National Health Commission to elevate and monitor the quality of training in medical schools and establish accreditation systems. In addition to training qualified PHC physicians, departments of general practice in medical colleges should also develop the academic discipline and nurture the next generation of teachers and leaders, who will drive the agenda of PHC development and generate the evidence that is needed to strengthen this field. Second, measures should be implemented to ensure that students attain an appropriate level of clinical competence, and be exposed to PHC throughout the training. Increasingly training should prepare them to work in multi-professional teams, and emphasis should be placed on the importance of doctor-patient communication, for example, empathy and shared decision-making, in building trust between patients and PHC providers. Third, the government could also consider setting targets for the percentage of medical graduates who would pursue post-graduate training in general practice,[64] and develop strategies for inspiring students to work in PHC, like exposing undergraduate medical students to PHC and community health service early in the curriculum.[65]

In the training for current PHC workforce, clinical practice guidelines need to be tailored for PHC settings and contain feasible and affordable recommendations, including a patient-centred perspective with integration of patients' goals.[66] These guidelines should focus on the use of cost-effective diagnostic approaches and treatment measures, rather than on, for example, disease aetiology or the pharmacology of medications. China would benefit from a body that oversees the development of disease management protocols, with involvement of PHC providers, which in turn could inform the training of PHC physicians on appropriate and contextualised use. Additionally, incentives would help to motivate PHC doctors to participate the Continuing Medical Education and other in-service training programs, such as providing certifications that are meaningful in their career development and ensuring incomes when they temporarily leave their posts for training.

In addition to doctors, the key role of nurses and other health workers in PHC should be recognized and promoted. Specifically, recent pilot projects on nurse practitioner training, including those that accept new graduates with bachelor degrees from School of Nursing in medical colleges, and others that assign mid-career nurses to practise in PHC institution, could be considered a promising way to strengthen PHC workforce, particularly for chronic diseases management.[67]

Establish performance accountability to incentivize high-quality and high-value care

There is a need for national quality measurement and improvement systems that are linked with incentives to ensure that practices are monitored, outcomes are assessed, and providers are held accountable. Systematic quality improvement requires not only comprehensive indicators, reliable data, and in-depth analysis, but also financial and non-financial incentive mechanisms. These measures need to be timely, accurate and actionable.

Relevant authorities, including the National Health Commission and the National Healthcare Security Administration, could consider strengthening capacity of departments responsible for health-care quality (e.g., the division of medical management in different levels of Health Commissions and national and local Medical Quality Management and Control Centers). The departments could be tasked with monitoring the quality of care provision and provide feedback and support to address gaps in quality.

Social health insurance program's payments to care providers should reward good performance and outcome. Meanwhile publicly available data on care quality could increase accountability, engender trust, and drive improvement. Performance in the management of NCDs such as hypertension is a prime candidate for such initiatives. The newly established National Primary Health Care Hypertension Management Office in China is an example (panel 5).

Integrate clinical care with basic public health services

China should consider combining the public health budget with the social health insurance budget and shifting the payment of PHC teams from fee-for-service to a capitation payment method.[68] The capitation payment rate should be risk adjusted and the rate should cover costs for providing health promotion, prevention, management, and clinical care by the PHC physicians and teams. This will encourage PHC physicians to coordinate preventive care with clinical care, thereby leading to better management and better outcomes for the patients.

The National Basic Public Health Service Program should consider emphasising that clinical care, including appropriate prescribing of tests and medications, is essential to achieve the goal of health management and disease control. At the national level, in addition to the CDC, the leading professional institutions related to the major diseases covered by the National Basic Public Health Service Program could be involved in task definition, guideline development, implementation monitoring, and performance assessment of the services. At the county level, an alliance between the CDC and the county hospital could assume responsibility for the guidance and monitoring of the National Basic Public Health Service Program. At the organisational level, PHC institutions should have full autonomy in personnel and financial management to optimise the resource allocation and payment incentive with the aim to integrate clinical care and basic public health services.

Most performance assessments of PHC institutions examine the quantity of public health services provided, but assessments should also include additional measures of clinical care processes (e.g., availability of basic medications and proportion of appropriate prescriptions) and patient health outcomes (e.g., avoidable hospitalization, incidence of stroke, heart attack, and premature death).

Strengthen the coordination between primary health care institutions and hospitals

To establish a medical alliance or integrated delivery system as encouraged by the State Council of China[69] and recommended globally,[70] PHC institutions and hospitals need to closely coordinate their functions. In addition to vertical technical support provided by

hospitals to the PHC institutions within the same catchment areas, deeper coordination between them should be implemented to best suit local contexts (panel 6), with integrated systems for staff training, medication supply, health IT support, equipment procurement, and most importantly, alignment of economic interests.[71]

To encourage PHC institutions and secondary or tertiary hospitals to coordinate, it is essential to change the provider payment mechanism from one that pays each facility separately, such as by fee-for-service, diagnosis-related-groups, to one that pays according to the size of the population served and the quality of care delivered. The aforementioned capitation payment methods should cover services at the primary care level as well as the secondary care hospitals, and eventually be extended to cover tertiary care level. The envisioned primary, secondary, and tertiary care team would jointly manage the capitated funds. If there were savings, they would be shared by the team. This gives incentives for the team to collaborate to invest in prevention and health maintenance and to shift the locus of care to PHC institutions to reduce costs. However, there need to be outcomes assessments to ensure that people are not adversely affected by the rationing of services to increase profit margins.

Improve information system towards building a learning primary health care system

An integrated electronic health record system per citizen is needed to improve the quality and efficiency in PHC institutions as well as the entire health care system (panel 7). China should address the challenges in the two core information technology (IT) systems in PHC institutions – the Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care.[5] First, clinical IT systems like Electronic Medical Records should be available in all PHC institutions, including village clinics. Second, the development and deployment of clinical IT systems in PHC institutions need to be centralised, with standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care,[72] to ensure integration and

interoperability. Third, the Residents Health Record System that was implemented nationwide in the National Basic Public Health Service Program should be integrated with the delivery of clinical care, to ensure that the health data can be used to facilitate appropriate and efficient clinical practice. Fourth, the Electronic Medical Record Systems in PHC should be linked with the ones used in secondary and tertiary hospitals to facilitate patient referrals.

Over time, China should aim to build a learning PHC system that is data-driven and technology-enabled, with a real-time, high-performance IT system that can capture, organise, and normalise data from many sources, maintain data securely, grant access to data selectively, and provide the computational power to rapidly analyse data. The system should be able to produce insights and discoveries about the temporal quality of services, the comparative effectiveness of alternative strategies, and the underlying causal factors for the results being achieved, as well as to make them available to policy makers and researchers.

Equally important, the system should ensure that professionals are practicing at the top level of their training and in accordance with the most up-to-date evidence, with the IT support. Specifically, based on integrated data platform, there could be three IT tools that apply innovative technologies for staff training, decision support, and quality control, working in synergy. First, in-service training tools that are extended through internet and mobile internet. Online training could be an efficient way to train millions of PHC professionals in a vast country with wide access to the internet.[73] Such digital learning could potentially facilitate adaptive and personalised courses based on individual abilities. Second, decision support tools that are enhanced by artificial intelligence (AI). In addition to the basic function of decision support tools, including guideline recommendations, dosage calculations, and contraindications alerts, AI algorithms can enable these tools to generate new knowledge with designedly analysing data from the ongoing delivery of care. Third, quality monitoring and feedback tools that are based on big data. Technologies can, on the one hand, facilitate data integration from multiple systems in quality monitoring, to provide a perspective on a broad array of the process and outcomes of care; on the other hand, enable targeted and

timely analysis, with performance benchmarks determined in consideration of the local epidemiologic profiles and PHC characteristics.

Conclusion

During the past decade of health care reform, China prioritised the investment in its PHC system. However, the system is currently facing challenges in providing high-quality and high-value care to the population because of the shortfalls in several dimensions. We suggest a series of recommendations for China to implement or pilot-test with the goal to improve quality of PHC. In time, these would transform China's delivery system from one that is hospital-centric to an integrated system anchored in PHC and enabled by the latest technology and data. A strong and high quality PHC system will help China to achieve the social benefits enshrined in the national Healthy China 2030 strategy.

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Author Contributions

SH conceived the review and take responsibility for all aspects of it. XL, HMK, and WY designed the study and wrote the first draft. KC and JLu participated in and made critical suggestions for interoperating the findings and generating the recommendations. JDM, QM, EAM, CL, MS, QZ, DRX, LL, SLN, RP, JLi, ZW, HY, RGa, SC, XG, RGu, HJ, YK, ZP, XW, SX, XX, YZ, JZ, and SZ participated in discussion and provided comments in revision. All authors approved the final version of the Review.

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Panels

Panel 1. Key messages

1. In China, there is evidence of widespread gaps in the quality of primary health care, which leads to suboptimal population health and significant economic impact.
2. The shortfalls of primary health care system include: lack of training and educational opportunities for the practitioners; the fee-for-service model that incentivizes unnecessary testing and treatments; lack of integration between clinical care and public health service, as well as between health care sectors; insufficient continuity of care throughout the entire health care system.
3. In addition to general practitioner education, China could consider tailoring continuing training for the current primary health care workforce, in which online platform could cover a vast number of professionals and facilitate adaptive programs based on individual abilities.
4. At primary health care level, clinical care and public health services need to be integrated, with respect to provider payment, guideline recommendations, and performance assessment, to bring synergy in disease and health management.
5. Coordination between primary care and hospital care can be incentivized through a population-based capitation payment system and an IT platform to match the capabilities of different institutions with the comprehensive needs of the population.
6. China needs performance measurement and accountability in its primary health care system, with comprehensive indicators, reliable data, and in-depth analysis, as well as financial and non-financial incentive mechanisms.
7. The primary health care system should increasingly be configured to be a learning platform for knowledge generation and utilization, which is built on digital data and innovative technologies, particularly for staff training, decision support, and quality control.

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721 **Panel 2. European Primary Care Monitoring System: dimensions and features of**

722 **primary care**

The European Primary Care Monitoring System was established to assess the primary care comprehensively in 31 European countries. An assessment framework was developed to create a model for holistic analyses of primary care, with relevance, precision, flexibility, and discriminating power. A panel of primary care experts conducted a systematic review of the primary care literature published between 2003 and July 2008, to generate an overview of: 1) the dimensions of primary care; 2) essential features per dimension; 3) applied indicators to measure the features. The resulting framework describes the key dimensions of primary care systems at three levels: structure, process, and outcome level (elaborated in the table below), which was inspired by Donabedian's health system analysis approach.[10]

Primary care dimensions and features

Level	Dimension	Feature
Structure	Governance of the primary care system	1. Health (care) goals; 2. Policy on equity in access; 3. (De)centralization of primary care management and service development; 4. Quality management infrastructure; 5. Appropriate technology in primary care; 6. Patient advocacy; 7. Ownership of primary care practices; 8. Integration of primary care in the health care system.
	Economic conditions of the primary care system	1. Health care expenditure; 2. Primary care expenditures; 3. Health care funding system; 4. Employment status of primary care workforce; 5. Remuneration system of primary care workforces; 6. Income of primary care workforce.
	Primary care workforce development	1. Profile of primary care workforce; 2. Recognition and responsibilities of primary care disciplines; 3. Education and retention; 4. Professional associations; 5. Academic status of primary care disciplines; 6. Future development of primary care workforce.

Process	Access to primary care services	1. Availability of primary care services; 2. Geographic access of primary care services; 3. Accommodation of accessibility (incl. physical access); 4. Affordability of primary care services; 5. Acceptability of primary care; 6. Utilisation of primary care services; 7. Equality in access.
	Continuity of care	1. Longitudinal continuity of care; 2. Informational continuity of care; 3. Relational continuity of care; 4. Management continuity of care.
	Coordination of care	1. Gatekeeping system; 2. Primary care practice and team structure; 3. Skill-mix in primary care; 4. Integration of primary care-secondary care; 5. Integration of primary care and public health.
	Comprehensiveness of primary care	1. Medical equipment available; 2. First contact for common health problems; 3. Treatment and follow-up of diseases; 4. Medical technical procedures and preventive care; 5. Mother/child/reproductive health care; 6. Health promotion.
Outcomes	Quality of primary care	1. Prescribing behaviour of primary care providers; 2. Quality of diagnosis and treatment in primary care; 3. Quality of chronic disease management; 4. Quality of mental health care; 5. Quality of maternal and child health care; 6. Quality of health promotion; 7. Quality of preventive care; 8. Effectiveness; 9. Practice safety.
	Efficiency of primary care	1. Allocative and productive efficiency; 2. Technical efficiency; 3. Efficiency in performance of primary care workforce.
	Equity in health	1. Equity in health.

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Panel 3. Literature search strategy

To summarise the findings of studies on China's primary health care system, we searched the PubMed/Medline and CNKI (China National Knowledge Infrastructure) database in October 2019 (appendix C), to identify relevant studies on seven domains of primary health care (structural, human resources, electronic health record system, financial, insurance, medications, and quality of care) in China. In the PubMed/Medline, we used MeSH and free text terms in conjunction to increase sensitivity to potentially appropriate literature. The MeSH terms include "primary health care", "General Practice", "General Practitioners", "Physicians, Family ", "Community Health Services", "Delivery of Health Care", and terms for each specific domain. Search terms and all their possible synonyms and spellings were identified and used in the search strategy. In the database of CNKI, we used similar strategy to include literature published in Chinese journals.

Panel 4. Hypertension control in primary health care, as well as the lifetime health and cost consequences in China

There are more than 270 million patients with hypertension in China.[74] However, in population based studies of hypertension using large samples done after the launch of the programme, nationwide or in specific regions of China,[25,30,31,75-79] increased prevalence, low awareness, low treatment, and poor control of hypertension were found (appendix F), as well as wide variation in the results because of differences in the methodologies (e.g., differences in sampling and age groups included) among studies. Based on two reported national representative surveys, approximately one in four adults had hypertension in the period 2012–25.[30,31] Awareness and treatment rates were unsatisfactory among patients with hypertension, which translated into poor control of blood pressure overall (9·7%[25] and 15·3%[31]).

Poor control of cardiovascular risk factors in the Chinese population could ultimately result in compromised health outcomes. Based on the findings in the largest study on hypertension management in China,[25] we used a state-transition simulation model to predict the lifetime health lost (appendix G).[80] Among 1·7 million Chinese adults aged 35–75 years, gaps in awareness of hypertension result in a total of an estimated 3 336 000 years of life lost and 3 829 000 quality-adjusted life years (QALYs) lost; the treatment gap results in an estimated 6 318 000 years of life lost and 7 251 000 QALYs lost; and the control gap results in an estimated 24 914 000 years of life lost and 28 657 000 QALYs lost.

The suboptimal risk control and lost opportunities to prevent or mitigate disease at the primary care level in China has also had tremendous cost consequences. In the same state-transition simulation mode, the projected costs of antihypertensive drugs, cardiovascular disease event and management, and productivity were predicted from the gaps in hypertension awareness, treatment, and control. It would cost ¥125 million (discounted at 3% per year) per year to fill the awareness gaps, but reaching that scenario would save

¥486 million annually in event costs averted (including both acute and chronic care costs); it would further prevent a discounted productivity loss of ¥2691 million and monetised QALY losses of ¥2609 million per year. Overall, the economic losses due to the gaps in hypertension awareness, treatment, and control would be ¥5661 million, ¥10 722 million, and ¥35 331 million per year.

Categories of economic impact due to gaps in hypertension awareness, treatment, and control (per year, in millions of 2015 yuan)

	Awareness gap	Treatment gap	Control gap
Decreased antihypertensive drug cost	151	286	1 029
Decreased antihypertensive drug cost (discounted)	125	237	854
Increased cardiovascular disease event cost	548	1 039	3 085
Increased cardiovascular disease event cost (discounted)	486	920	2 725
Productivity loss	3 064	5 802	18 230
Productivity loss (discounted)	2 691	5 097	15 938
Monetized discounted quality-adjusted life years lost	2 609	4 942	17 521
Total economic loss	5 661	10 722	35 331

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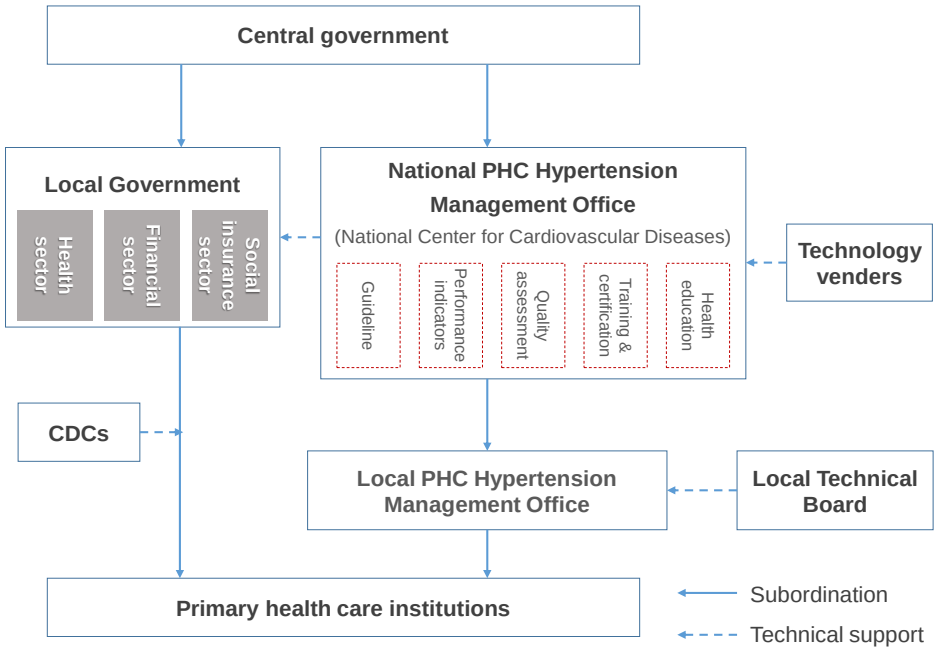
732 **Panel 5. A national initiative on improving primary health care – the National Primary**

733 **Health Care Hypertension Management Office**

The National Primary Health Care Hypertension Management Office was established in March 2017 with the charge to develop strategies and practices to improve hypertension management nationwide and to serve as a model for other services in the program (see figure below).



New model for primary health care hypertension management in China

CDC: Center for Disease Control and Prevention

In practice, the Office developed five key strategies: 1) a new clinical practice guideline; 2) a set of performance indicators; 3) a quality assessment system; 4) training and certification mechanisms; and 5) health education platforms.

Clinical practice guideline

With significant input from clinical and public health opinion leaders, WHO experts, policymakers, and representatives of primary care professionals, the guideline was developed with the premise that optimal primary health care must satisfy four key elements: it must be evidence-based, streamlined, practical, and affordable. To facilitate the application, a toolkit was released to provide a visual representation of the clinical pathway. In addition to clinical recommendations, the guideline also states the regulatory requirements and assessment indicators for primary health care hypertension management teams.[81]

Performance indicators

Eight indicators for disease management were included: 1) evidence-based prescription rate; 2) blood pressure control rate; 3) standard follow-up rate; 4) incidence of cardiovascular events, such as stroke and myocardial infarction; 5) staff success rate in completing the training program; 6) availability of antihypertensive medications; 7) standard management rate; and 8) patients' compliance to hypertension treatment.

Quality assessment data collection system

Key information of hypertension diagnosis, treatment, and prognosis is entered in real time at the baseline and follow-up visits at primary health care institutions through a customized developed electronic data collection system. Periodical reports based on a predefined analysis plan are generated automatically and sent to various users including policymakers and institution managers.

Physician training and certification platform

A comprehensive free-of-charge platform (Yun-que, Xiong-ying, and Qun-yan) that provides both online and offline training sessions was established in Jan 2018. Within 1 year, more than 1·51 million physicians from 0·34 million primary health care institutions

nationwide registered for the Yun-que online training program, 0·78 million of whom were certified after successful completion. Through the use of health IT, personalized training modules are developed based on the evidence of strengths and weaknesses in practice. The Xiong-ying and Qun-yan programs have also held 27 offline training sessions, and trained more than 2000 individuals to assist practicing physicians.

Health education platform

The Office developed a bank of health education messages using behavioural change techniques applicable to the Chinese cultural context and compatible with Chinese beliefs and values. Primary care professionals can receive messages periodically from the bank through an application on their computers or smart phones, and push the messages to the most relevant persons (e.g., smoking cessation counselling for smokers), using short messages, or via Instant Messenger and social networks.

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Panel 6. How has Shenzhen been reforming its primary health care system?

Shenzhen, a megacity in Southern China, is globally known for its rapid economic development and technological innovation. The average life expectancy for its 13 million permanent residents is 81 years, similar to that of the United Kingdom. There are 686 community health centres in Shenzhen, which provided 27·5 million clinical visits (about 30% in total) in 2017. Since 2016, the municipal government of Shenzhen has implemented a series of policies to strengthen its primary health care system by establishing primary care groups, which are networks of integrated management, shared responsibilities, and common interests.

Integrated Management

To set up tight Medical Alliances (医联体), the Shenzhen municipal government has established a primary care group, as independent legal entities in each district, to integrate distribution of medical resources, care delivery, and information utilization in primary health care institutions and hospitals. As the core of a primary care group, the tertiary general hospital has full autonomy in personnel and financial management of all the public community health centres within.

Health care professionals working in community health centres are employed by primary care groups and share the same salary standards and social insurance packages with their counterparts working in hospitals. Moreover, physicians in primary health care institutions have extra benefits compared with their counterparts in hospitals, including special subsidies from the government and more opportunities for technical post promotion.

Similar to physicians in tertiary and secondary hospitals, doctors in community health centres can prescribe any medication in the social medical insurance medication list issued by the government, including 48 antihypertensive drugs and 15 antidiabetic drugs. Meanwhile, medication availability is ensured by the unified delivery system covering both community health centres and hospitals throughout the city.

Primary care groups use the unified electronic health record system to ensure that information is interoperable across institutions. In addition, three databases at the municipal level have been consolidated to inform health care management, including the electronic medical records across all levels of clinical care, digital health records with basic public health documents for every resident, and population records with vital registration and demographic information of the entire population.

Shared Responsibilities

The primary care groups are responsible for the full range of clinical care needs of local residents, whereas tertiary hospitals mainly provide emergency and inpatient care and community health centres handle common clinical visits and basic public health services. In order to quickly strengthen the diagnosis and treatment capabilities of community health centres, a new pattern of tests in community health centres, diagnosed by the group based on telemedicine services within the primary care group, has been introduced and validated. In addition, the prescriptions from each community health centre are centrally reviewed by the pharmacist team in the local secondary hospitals.

Each individual resident has a contracted family doctor team that consists of specialists from tertiary hospitals and primary health care physicians from community health centres who are collectively expected to provide comprehensive and continuing care. Thus, establishing networks of teams has been a central function of primary care groups and a focus of health policies. Other sections of the health care system, including public health agencies and nursing institutions, are also now participating in the routine work of teams.

Several policies have been implemented to tighten the connections between members of the primary care group in care delivery. Public hospitals have established specialty clinics in 432 (60%) local community health centres, which have significantly improved the accessibility and quality of clinical care at the community level, with the price of services 20% lower than in tertiary hospitals and the health insurance reimbursement rates 30%

higher. Also, patients referred from community health centres have priority in outpatient visits, clinical tests, and hospital admissions in the hospitals, which has greatly promoted coordination within primary care groups.

Common Interests

The government of Shenzhen has implemented a needs-based capitation approach in social health insurance reimbursement, accompanied with differentiate pricing policies, to incentivize primary care groups to save costs. Each patient's annual capitation paid the providers by the government is mainly determined by his/her total health insurance payment during the last year. If the actual reimbursement amount this year is smaller than the capitation, the surplus can be kept by the patient's contracted primary care group. As a result, in the primary care groups, hospitals and community health centres have been collaborating to develop and implement strategies that save cost through, for example, containing outpatient visits to the community health centres where the price of services is 20% lower than in hospitals, prioritizing risk control and disease prevention, or reducing unnecessary use of advanced facilities. Meanwhile, patients are also incentivized to go to community health centres, since their out-of-pocket payment there (about 10% of the total cost) could be substantially reduced compared with what they would pay at hospitals (about 30% of the total cost) due to higher insurance coverage and lower price of services.

In the wake of the zero drug mark-up policy, the municipal Health Commission intends to incentivize health care providers to actively meet the clinical needs of the population via a subsidy system for medical services. Hospitals and community health centres can receive a 30-yuan subsidy from the government for each outpatient visit, regardless of the actual charge during the visit. Thus, the mechanism encourages physicians to deliver more services, rather than to prescribe more testing or drugs. Since 2017, the subsidy for community health centres has increased to 40 yuan per outpatient visit, so that the primary

care groups are shifting their focus of outpatient care from hospitals to community health centres within.

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Panel 7. Integrated National Electronic Health Records: experiences on information technology for primary health care in Finland

In Finland, each of the 5·3 million citizens has a Personal Health Record, which is integrated into a national repository known as the eArchive. These together provide a centralized location for patients, health care providers, pharmacies, and social workers to keep track of patient information, communicate with each another, and make informed clinical decisions. Each patient is listed under a primary health care institution that takes full responsibility for the patient's integrated care, and patients have control over which social workers and health care professionals have access to their information. All patients have secure access to their own records over the Internet using their bank account credentials, mobile identity verification, or an electronic identity card. Patients use the system to fill prescriptions and update their health information in their Personal Health Records with home measurements including blood pressure, peak expiratory flow, blood glucose, diet, and exercise. Electronic communication between professionals and patients is supported by symptom checkers and follow-up forms, secured messages, or real-time chat.

The care is linked to decision-support tools (e.g., guidelines of the most frequent problems encountered in primary health care) and also artificial intelligence that can help practitioners implement guidelines (e.g., the system checks if a medication prescribed by the family physician is compatible with the renal function of the patient and if not, proposes alternatives). In cases of referral, the information in the Personal Health Record is accessible by the specialist providers.

Appendix

A. Phases of development of primary health care in China

Since the establishment of the People's Republic of China in 1949, its primary health care system has gone through three major phases.

From the 1950s to the 1970s

China received global recognition for its achievements in health improvement and health system development. Its success was particularly notable in the rural areas, where overall health status improved in a relatively short period despite extremely scarce resources. The three-tiered health care delivery system, so-called "barefoot doctors" at village clinics, and low-cost universal health insurance (cooperative medical scheme) were considered the three key elements of its success. The three-tiered health care delivery system in rural areas comprises the clearly defined and well-operated functions of three levels of health providers and organization at the village, township, and county level. In parallel, a similar health care delivery structure was developed in urban areas comprised of three levels of health organizations at the street (now called community), district, and municipal level. China's strategy of focusing on the provision of preventive care and basic curative care at an affordable cost (through insurance coverage and low-cost services) was considered a model of health system development, and the country was intensively involved in the development of the 1978 Alma-Ata Declaration. Core primary health care concepts and policies within the Declaration, including full governmental support, accountability for health, inter-sectorial cooperation on health, affordable health care, education, and a comprehensive development system, were derived from China's successful experiences. The context within which China developed its health system was similar to that of many low-income countries, which was a key factor in the acceptance of the Chinese primary health care model by other developing countries when designing their own health systems.

From the 1980s to the early 2000s

The Chinese primary health care system faced challenges as a result of the central government reducing its role in health care financing and insurance organization. Insurance coverage rates under the cooperative medical scheme decreased from 95% in 1976 to 5% in 1985.[82] After several failed attempts to raise funds for health care, the Ministry of Health began emphasizing the importance of self-reliance, and it pursued alternative funding through market-oriented reform.[83] The integrated three-tiered health care delivery system was dismantled as health providers at the village level became privatized, while township-level and county-level hospitals/health centres became self-financing. Preventive care was phased out in favour of the higher revenues provided by curative care. Moreover, hospitals grew in number and scope of services, attracting an increasing number of patients in this competition with the primary health care system.[4,36] Thus the prior advantage in health care efficiency of China, in comparison with other countries with similar levels of development, was gradually losing. Rural health centres, in particular, experienced enormous difficulty under the market-oriented reforms. As the primary health care institutions deteriorated and relied on revenue from user fees, the public health functions of these facilities greatly diminished. During this time, China was widely criticized by both national and international academic and health care organizations for its inability to extend primary health care coverage to all. In its 2000 annual report, WHO ranked China at the bottom fourth of its 191 member states in terms of equitable financial health protection.[84]

From the early 2000s to the present

A policy report commented that "China's health care reform since 1978 was in general a failure".[85] This report, combined with public complaints about health care, were the driving forces behind a new phase of system reform. The government began to re-establish the rural health insurance system in 2003 and the urban resident health insurance system in 2007. A more comprehensive reform agenda, developed by a number of line ministries with technical support from academic institutions, was implemented in 2009. Since then, strong primary health care has been a key strategy of health care reform in addition to universal health insurance coverage, a National Essential Medicines System, and basic public health services. The government increased its subsidies to primary health care institutions from 19 billion RMB in 2008 to 197 billion RMB in 2018.[3,4] Acknowledging the increasing pressure exerted by an aging population, behavioural changes,[86] and rapid urbanization,[87] the Healthy China

2030 plan issued in 2016 envisions the primary health care system as a means of addressing the emerging dual burden of chronic NCDs and increasing health expenditures.[88]

B. Institutions providing primary health care in China

In 2015, the Chinese State Council issued the Plan for the Health Care Delivery System (2015–2020), in which various health care organisations and their functions were defined.[51] The primary health care system in China is divided into urban and rural components, each with a two-tier structure. Most of the institutions in this system are publicly owned (ie, the institutions are owned by all or a specific group of Chinese citizens).[4,36] In 2018, urban components included approximately 9300 community health centres and, one level below them, 25 600 community health stations. Rural components included approximately 36 400 township health centres and, one level below them, 622 000 village clinics.[4]

In addition to the four types of care institutions above, there are about 228 000 community clinics (96% privately owned), 21 600 clinics belonging to individual organisations such as schools and companies (34% privately owned),[36] and many community pharmacies (most privately owned). The community clinics mainly provide medical care in specific fields such as dental disorders or traditional Chinese medicine (TCM). The clinics belonging to organisations provide health care services only to employees or students of the organisation. These clinics and pharmacies are important parts of clinical care delivery, as they supplement the primary health care system. Moreover, a growing number of private health management companies scattered in large cities are providing medical examination, disease screening, and outpatient services too.

C. Method of literature searching

We searched the PubMed/Medline and CNKI (China National Knowledge Infrastructure) database in October 2019, to identify relevant studies on seven domains of primary health care (structural, human resources, electronic health record system, financial, insurance, medications, and quality of care) in China. Search terms and all their possible synonyms and spellings were identified and used in the search strategy (Table A-1). In the database of CNKI, we used similar strategy to include literature published in Chinese journals (Table A-1).

Table A-1 English literature from PubMed/Medline

Search topic	Query	Items found
EHR system	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Electronic Health Records"[Mesh] OR “Hospital Information Systems"[Mesh] OR "information technology"[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	58
Medications	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family"[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND ("Drugs, Essential"[Mesh] OR “Medication Systems"[Mesh] OR “Medicine, Chinese Traditional”[Mesh]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	534
Quality	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Health Services Accessibility"[Mesh] OR “Healthcare	10294

Search topic	Query	Items found
	Disparities"[Mesh] OR “Practice Patterns, Physicians'"[Mesh] OR “Practice Patterns, Nurses'"[Mesh] OR “Professional-Patient Relations"[Mesh] OR “Health Services Research"[Mesh] OR “Quality of Health Care"[Mesh] OR "quality"[Title/Abstract] OR "performance"[Title/Abstract]OR behaviour [Title/Abstract] OR behaviors [Title/Abstract] OR behaviour [Title/Abstract] OR behaviours [Title/Abstract] OR "disparities"[Title/Abstract] OR "disparity"[Title/Abstract] OR "gap"[Title/Abstract] OR "gaps"[Title/Abstract] OR "measure"[Title/Abstract] OR "measurements"[Title/Abstract] OR "adherence"[Title/Abstract] OR Inequity[Title/Abstract] OR equity[Title/Abstract] OR inefficiency[Title/Abstract] OR efficiency[Title/Abstract] OR efficient[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	
Human resources	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“manpower"[Mesh] OR “Education, Public Health Professional"[Mesh] OR “Education, Professional"[Mesh] OR “Education, Medical, Continuing"[Mesh] OR “Professionalism"[Mesh] OR “Career Choice"[Mesh] OR “Career Mobility"[Mesh] OR "human resources"[Title/Abstract] OR "retention"[Title/Abstract] OR "incentives"[Title/Abstract] OR "salary"[Title/Abstract] OR "professional medical master"[Title/Abstract] OR Motivation[Mesh] OR “Salaries and Fringe Benefits”[Mesh] OR “Staff Development”[Mesh] OR “Inservice Training”[Mesh] OR “Training Support”[Mesh] OR “Physician Incentive Plans”[Mesh] OR “Employee Incentive Plans”[Mesh] OR “Personnel Management”[Mesh] OR “Health Resources”[Mesh] OR incentive[Title/Abstract] OR motivation[Title/Abstract] OR motivations[Title/Abstract] OR motivating[Title/Abstract] OR salaries[Title/Abstract] OR income[Title/Abstract] OR wage[Title/Abstract] OR wages[Title/Abstract] OR "financial reward"[Title/Abstract] OR "financial rewards"[Title/Abstract] OR "fringe benefit"[Title/Abstract] OR "fringe benefits"[Title/Abstract] OR train[Title/Abstract] OR training[Title/Abstract] OR trainings[Title/Abstract] OR scholarship[Title/Abstract] OR scholarships[Title/Abstract] OR education[Title/Abstract] OR educational[Title/Abstract] OR "career development"[Title/Abstract] OR "development opportunity"[Title/Abstract] OR "development opportunities"[Title/Abstract] OR "resource availability"[Title/Abstract] OR "resources availability"[Title/Abstract] OR "working condition"[Title/Abstract] OR "working conditions"[Title/Abstract] OR "work condition"[Title/Abstract] OR "work conditions"[Title/Abstract] OR "working environment"[Title/Abstract] OR "working environments"[Title/Abstract] OR "work environment"[Title/Abstract] OR "work environments"[Title/Abstract] OR "human resource management"[Title/Abstract] OR "human resources management"[Title/Abstract] OR "personnel management"[Title/Abstract] OR “Personnel Turnover”[Mesh] OR “Emigration and Immigration”[Mesh] OR Personnel Loyalty[Mesh] OR “Professional Practice Location”[Mesh] OR attraction[Title/Abstract] OR attracting[Title/Abstract] OR attract[Title/Abstract] OR attracted[Title/Abstract] OR attracts[Title/Abstract] OR retaining[Title/Abstract] OR retain[Title/Abstract] OR retained[Title/Abstract] OR retains[Title/Abstract] OR recruitment[Title/Abstract] OR recruiting[Title/Abstract] OR recruit[Title/Abstract] OR recruited[Title/Abstract] OR recruits[Title/Abstract] OR migration[Title/Abstract] OR migrate[Title/Abstract] OR migrating[Title/Abstract] OR migrated[Title/Abstract] OR migrates[Title/Abstract] OR immigration[Title/Abstract] OR immigrate[Title/Abstract] OR immigrating[Title/Abstract] OR immigrated[Title/Abstract] OR immigrates[Title/Abstract] OR emigration[Title/Abstract] OR emigrate[Title/Abstract] OR emigrating[Title/Abstract] OR emigrated[Title/Abstract] OR emigrates[Title/Abstract] OR mobility[Title/Abstract] OR turnover[Title/Abstract] OR "brain drain"[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published	6040

Search topic	Query	Items found
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Insurance	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Insurance, Health"[Mesh] OR “out-of-pocket”[Title/Abstract] OR “New Rural Cooperative”[Title/Abstract] OR affordability[Title/Abstract] OR affordable[Title/Abstract] OR catastrophic[Title/Abstract] OR "urban resident basic medical insurance"[Title/Abstract] OR "cooperative medical scheme "[Title/Abstract] OR "NCMS"[Title/Abstract] OR “financial protection”[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	647
Financial	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Healthcare Financing"[Mesh] OR “Remuneration"[Mesh] OR “Capital Financing"[Mesh] OR "Health Resources"[Mesh] OR “Resource Allocation"[Mesh] OR payment[Title/Abstract] OR subsidy[Title/Abstract] OR subsidies[Title/Abstract] OR budget[Title/Abstract] OR fund[Title/Abstract] OR resource[Title/Abstract] OR resources[Title/Abstract] OR resourcing[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	1540
Structural	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centres"[Title/Abstract] OR "township health centres"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "village clinics"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centres"[Title/Abstract] OR "community health centres"[Title/Abstract]) AND (“Organization and Administration"[Mesh] OR “Health Policy"[Mesh] OR “Organizational Policy"[Mesh] OR “Referral and Consultation"[Mesh] OR “gatekeeping"[Mesh] OR gatekeeper[Title/Abstract] OR governance[Title/Abstract] OR reform[Title/Abstract] OR referral[Title/Abstract] OR “integrated health care”[Title/Abstract] OR “three tier health care system”[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient	3276

Search topic	Query	Items found
	Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	

Table A-2 Chinese literature from Chinese National Knowledge Infrastructure (CNKI)

Search topic	Query	Items found
Structural	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='组织'+'框架'+'结构'+'改革'+'转诊'+'协同'+'配合'+'分工'+'分级诊疗'	Journal articles: 415 Doctoral thesis: 4 Master thesis: 62
Financial	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='经费'+'资金'+'财政'+'支出'+'收入'+'收支'+'补偿'+'拨款'+'拨付'+'药品零差'	Journal articles: 133 Doctoral thesis: 4 Master thesis: 19
Insurance	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='医保'+'保险'+'自付'+'报销'+'新农合'+'新型农村合作医疗'+'封顶'+'起付'+'拨款'+'拨付'+'药品零差'+'救助'	Journal articles: 63 Doctoral thesis: 2 Master thesis: 16
Human resources	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='人力资源'+'人员流动'+'薪酬'+'激励'+'职业发展'+'职业规划'+'培训'+'技能'+'人员能力'+'教育'+'轮转' AND HX=Y	Journal articles: 161 Doctoral thesis: 3 Master thesis: 59
Quality	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND AB='医疗质量'+'服务质量'+'患者满意'+'用药合理性'+'合理用药'+'医疗安全'+'服务效率'+'依从性'+'循证'+'同质'+'医疗可及性'+'服务可及性'	Journal articles: 699 Doctoral thesis: 37 Master thesis: 304
EHR system	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='信息系统'+'电子病历'+'信息技术'+'数据'+'健康档案'	Journal articles: 88 Doctoral thesis: 1 Master thesis: 21

Search topic	Query	Items found
Medications	TI=‘基层卫生’+’基层医疗’+’初级卫生’+’社区医疗’+’社区卫生’+’乡村医疗’+’乡村卫生’ AND TI=‘基本药物’+’基药’+’药品供应’+’药品零差’+’药品加成’+’药品定价’+’药政’+’药品管理’	Journal articles: 153 Doctoral thesis: 2 Master thesis: 36

D. Evolution of the National Basic Public Health Service Program

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Funding, Yuan per capita	15	15	25	25	30	35	40	45	50
Residents' health records	√	√	√	√	√	√	√	√	√
Health education	√	√	√	√	√	√	√	√	√
Child health management	√	√	√	√	√	√	√	√	√
Maternal health care	√	√	√	√	√	√	√	√	√
Elderly health management	√	√	√	√	√	√	√	√	√
Vaccination	√	√	√	√	√	√	√	√	√
Reporting of infectious diseases and public health emergencies	√	√	√	√	√	√	√	√	√
Health management for hypertension	√	√	√	√	√	√	√	√	√
Health management for type-2 diabetes	√	√	√	√	√	√	√	√	√
Health management for psychosis	√	√	√	√	√	√	√	√	√
Health supervision	–	–	√	√	√	√	√	√	√
Traditional Chinese medicine health management	–	–	–	–	√	√	√	√	√
Health management for tuberculosis	–	–	–	–	–	–	√	√	√
Contraceptive device	–	–	–	–	–	–	–	–	√
Health promotion	–	–	–	–	–	–	–	–	√

E. The scope of the clinical care provided in primary health care institutions in China

Clinical conditions	Community health center	Community health station	Township health center	Village clinics
Cold	14.5%	19.1%	13.6%	19.5%
Hypertension	11.0%	11.5%	7.9%	9.8%
Diabetes mellitus	9.6%	9.0%	4.6%	4.6%
Chronic bronchitis	8.7%	8.6%	8.5%	10.5%
Acute bronchitis	8.1%	8.6%	9.0%	10.7%
Gastritis	6.5%	8.4%	7.5%	10.3%
Diarrhea	4.5%	6.7%	5.3%	11.7%
Urinary tract infection	4.1%	3.1%	4.5%	2.9%
Osteoarthritis	3.0%	2.3%	2.4%	0.5%
Low back pain	2.8%	1.5%	2.5%	0.8%
Psoatic strain	2.7%	2.3%	2.6%	0.8%
Peptic ulcer	2.1%	2.0%	2.9%	1.7%
General trauma	2.0%	1.3%	3.1%	1.1%
Sciatica	2.0%	0.6%	1.8%	0.3%
Child dyspepsia	2.0%	4.4%	3.2%	7.0%
Pelvic inflammatory disease	1.9%	0.4%	2.7%	0.6%
Vaginitis	1.8%	0.4%	2.7%	0.5%
Dysmenorrhoea	1.7%	1.2%	2.3%	0.5%
Cholecystitis	1.6%	1.4%	2.6%	1.6%
Toothache	1.5%	3.6%	1.3%	2.7%
Menopausal syndrome	1.4%	0.2%	1.4%	0.1%
Cholelithiasis	1.0%	0.5%	1.6%	0.4%
Idiopathic headache	0.8%	0.6%	0.6%	0.2%
Haemorrhoids	0.7%	0.5%	1.1%	0.4%
Asthma	0.6%	0.1%	0.6%	0.2%
Chronic dermatitis	0.5%	0.3%	0.2%	0.1%
Tympanitis	0.5%	0.4%	0.7%	0.2%
Conjunctivitis	0.5%	0.3%	0.6%	0.1%
Purulent skin infection	0.4%	0.1%	0.5%	0.0%
Sinusitis	0.4%	0.5%	0.6%	0.3%
Convulsion in children	0.3%	0.0%	0.3%	0.0%

To understand the scope of the clinical care provided in primary health care institutions in China, we asked the 10,626 primary health care physicians and village doctors involved in our survey to identify the top five clinical conditions that they encounter in regular practice. In community health centres and community health stations, the most commonly identified conditions were common cold (14·5% and 19·1%, respectively), followed by hypertension (11·0% and 11·5%), diabetes (9·6% and 9·0%), chronic bronchitis (8·7% and 8·6%), and acute bronchitis (8·1% and 8·6%). Doctors at township health centres and village clinics identified common cold (13·6% and 19·5%, respectively), acute bronchitis (9·0% and 10·7%), and chronic bronchitis (8·5% and 10·5); however, they more often identified

gastritis (7·5% and 10·3%) and diarrhea (5·3% and 11·7%) than hypertension (7·9% and 9·8%) and diabetes (4·6% and 4·6%).

F. Prevalence, awareness, treatment, and control rates of hypertension from large-sample population studies after 2009

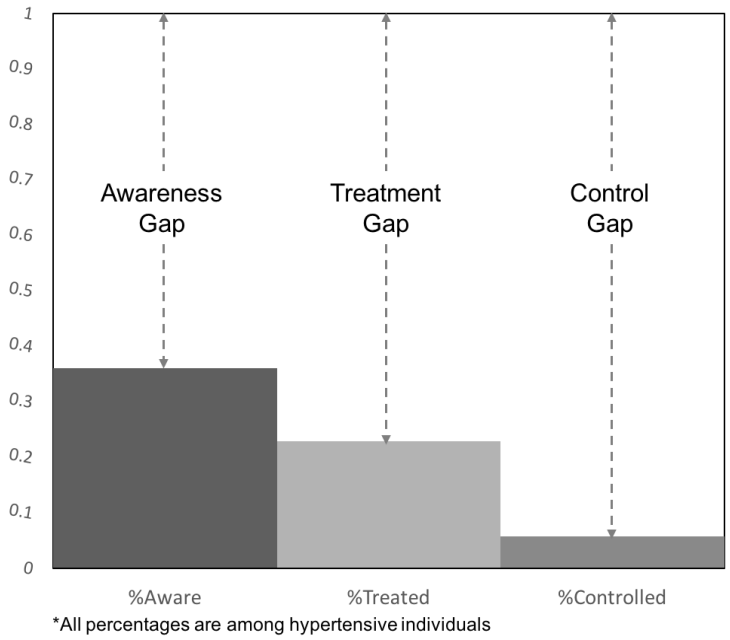
Study	Year of study	Population (years)	Sampling	Number of sites	Sample size	Prevalence (%)			Awareness (%)			Treatment (%)			Control (%)		
						Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Wang ZW, et al. 2018 [31]	2012 - 2015	≥18	Stratified multistage random sampling	262 (city level) from 31 provinces	451 755	23·2	23·1	23·4	46·9	44·7	50·9	40·7	38	45·8	15·3	13·1	19·4
Lu JP, et al. 2017 [25]	2014 - 2017	35-75	Convenience sampling	141 (county level) from 31 provinces	1 738 886	44·7	46·1	42·5	44·7	43·8	46·3	30·1	28·2	33·4	7·2	6·1	9·1
Li YC, et al. 2016 [30]	2013 - 2014	> 18	Stratified multistage random sampling	605 (county level) from 31 provinces	174 621	27·8	31·6	32·3	31·9	20·1	32·5	26·4	14·9	26·8	9·7	5·5	10·1
Yang L, et al. 2016 [76]	2013	≥15	Stratified multistage random sampling	10 (city level) from Zhejiang province	19 254	24·6	25·2	24·1	67·4	64·7	70·2	55·8	53·3	58·2	30·8	26·2	35·4
Fan L, et al. 2014 [79]	2012	15-74	Stratified multistage cluster sampling	30 (county level) from Henan province	18 772	26·6	NA	NA	46·0	NA	NA	35·7	NA	NA	10·4	NA	NA
Yin MH, et al. 2016 [77]	2011 - 2012	≥ 45	Four-stage stratified cluster sampling	150 (county level) from 28 provinces	13 583	41·7	NA	NA	57·9	NA	NA	46·4	NA	NA	23·4	NA	NA
Bi ZQ, et al. 2014 [75]	2011	18-69	Four-stage cluster sampling	20 (county level) from Shandong province	14 230	23·4	24·6	20·8	34·5	31·4	42·9	27·5	24·6	35·6	14·9	13·9	17·7

NA: not available.

G. Lifetime health and cost consequences prediction based on a state-transition simulation model

We used a state-transition simulation model to predict the lifetime health and cost consequences of cardiovascular disease (CVD) and hypertension in the 1.7 million individuals in the China Patient-centred Evaluative Assessment of Cardiac Events (China PEACE). Specific outcomes include life expectancy, Quality-adjusted Life Years (QALYs), antihypertensive drug cost, CVD event cost, chronic CVD management cost, and productivity. The projected health and economic effects are rescaled and age- and gender- standardized to represent the entire Chinese population aged 35 to 75 years.

In the model, we simulated four scenarios for different proportions of hypertension awareness, treatment and control: 1) Current, 2) All-aware, 3) All-treated, and 4) All-controlled. The "all-aware" scenario assumes that all hypertensive individuals are diagnosed but the diagnosed individuals are only proportionally treated and controlled; the "all-treated" scenario assumes that all hypertensive individuals are treated but the treated individuals are only proportionally controlled (based on the treatment and control proportions in the current scenario); and the "all-controlled" scenario assumes that all hypertensive individuals are controlled. Therefore, the "awareness gap" is defined as the gap between the all-aware scenario and the current scenario; the "treatment gap" is defined as the gap between the all-treated scenario and the current scenario; and the "control gap" is defined as the gap between the all-controlled scenario and the current scenario (see the figure below).



H. Primary health care professionals in China

Primary health care requires multidisciplinary professional teams that consist of doctors, nurses, pharmacists, and other health workers. Different types of primary health care professionals, and the synergy between them, are crucial for the system to provide comprehensive and high-quality services. In 2018, the primary health care workforce consisted of approximately 1 310 000 physicians, 907 000 village doctors, 852 000 nurses, 147 000 pharmacists, and 106 000 technicians.[4,36] As the backbone of the workforce, primary health care physicians and village doctors in China have a unique portfolio in comparison with other countries. There were 471 000 licensed physicians or licensed assistant physicians in urban areas, and 834 000 licensed physicians or licensed assistant physicians in addition to 907 000 village doctors in rural areas.[4,36] It takes 5 years of medical education after 12 years of primary and secondary education to become a licensed physician or 3 years of medical education after 12 years of primary and secondary education to become a licensed assistant physician, and regular and assistant physicians must pass the national practicing doctor (or assistant doctor) examination and periodic government assessments to maintain their licenses.

It is worth noting that most physicians in China have not been trained to be, or qualify as, general practitioner as it is defined in many other countries, since the development of China's general practitioner training system began in 2011. Village doctors need only a technical school education (3 years of medical education after 9 years of primary and secondary education) or 20 years of continuous practicing experience to work in village clinics. Village doctors practice with a village doctor certificate, rather than a regular license, and cannot practice in other types of health care institutions.

I. Relevant key features of the State Council guidance on reform and development of training and incentive mechanisms for general practitioners

Goals: To establish a comprehensive primary health care physician training system, to have five qualified primary health care physicians available for every 10 000 residents in China by 2030.

Establish and strengthen a comprehensive primary health care physician training system

- Deepening undergraduate medical education reform
  - Medical schools should attach high importance to the development of general practice. All medical students should receive training in the principles and practice of general practice. Medical schools should be encouraged to develop a unit dedicated to general practice.
  - Qualified primary health care physicians with teaching potentials should be encouraged to become teaching faculty.
  - Continue the implementation of tuition sponsorship for medical students who commit to primary health care physician residency training after graduation in rural areas.
- Develop a postgraduate primary health care physician training system
  - General practice should be given preferential consideration with newly created standardised residency training positions, with the aim of 20% of total positions dedicated to general practice by 2020.
  - General hospitals that have been certified as bases for standardized residency training should intensify general practice training. They should establish clinical units of general practice and jointly train primary health care physicians with primary health care institutions.
  - Training standards for primary health care physician trainers should be formulated. Promotion of the trainers will be dependent upon the quality of their teaching. Hospitals that are standardized residency training bases are encouraged to collaborate closely with medical schools.
- Strengthen continuous medicine education (CME) in general practice
  - Develop training guidelines on CME for primary health care physicians
  - Intensify the development of web-based programs. Enhance the role of county-level hospitals in providing CME for primary health care physicians in rural areas.
  - Strengthen training on traditional Chinese medicine and rehabilitation in CME.
  - Encourage hospital doctors from other specialties to be re-trained to become primary health care physicians.

Improve career attractiveness of primary health care physicians

- Reform the remuneration system for primary health care physicians
  - Raise the salary level of primary health care physicians at primary health care institutions to levels equivalent to physicians within local county-level hospitals. Establish a mechanism of salary growth linked to a pay-for-performance model.
  - Encourage primary health care institutions to recruit primary health care physicians who have completed standardized residency training.
  - Include fee for "family doctor service" as an income component of primary health care institutions. Use patients' satisfaction rates and health outcomes as indicators of performance and link this with income.
- Improve the employment and management of primary health care physicians
  - County-level hospitals can recruit and allocate primary health care physicians who have undergone standardised residency training to their subordinate township health centres. Similarly, township health

centres can recruit assistant primary health care physicians who have undergone training and allocate them to village clinics.

- Introduce special measures for primary health care physicians who have completed the standardized residency training to enhance their prospects for promotion.
- Encourage non-governmental organizations to set up primary health care physician clinics. A two-way referral system should be encouraged between general hospitals and these primary health care physician GP clinics. Primary health care physician clinics operating on a non-profit basis should be allowed to enjoy similar benefits and support as government-run primary health care institutions.
- Elevate the social status of primary health care physicians with local and national awards.

Strengthen the development of primary health care physician capacity in deprived areas

- Prioritize the allocation of assistant primary health care physicians who graduate from tuition sponsoring schemes to village clinics and township health centres in deprived and remote areas. Develop free online CME for primary health care physicians working in remote areas.
- Expand the scope of "special primary health care physician posts programs" (posts created in addition to those in established budgets) for deprived rural areas by increasing the financial subsidy for such programs from central and local government treasuries.
- Introduce special measures to enhance prospects for promotion for those who have practiced in deprived areas for more than ten years after completing standardised residency training.

Safeguarding the implementation of policies

- Strengthen organizational arrangements to ensure implementation of the above measures
- Explore new mechanisms whereby financial rewards are provided to primary health care professionals through using capitation fees from "family doctor service", and a fee to be paid by family doctor teams to the hospital if a patient is referred.
- Ensure that all levels of government and other sources provide adequate funding for these measures, which will be closely monitored.
- Include primary health care physician training and implementation of this guidance as a part of the assessment of progress in health care reform, with regular investigations and supervision.
- Create a positive image of primary health care physicians and their roles through various forms of publicity.

Quality of Primary Health Care in China: Challenges and Recommendations

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Executive Summary

As part of its health care reform~~D~~ in the past decade, China has significantly increased financial~~espite the increasing~~ investment and introduced favourable policies for primary health care. However ~~as part of the nation's health care reform~~, ~~there is evidence of~~ widespread gaps in the quality ~~of primary health care~~ still exist, which has contributed to missed opportunities to promote population health ~~in China.~~. In this review, we aim to identify the causes for poor quality, and provide policy recommendations for improvement. These gaps include suboptimal screening, diagnosis, and treatment of diseases, which ~~lead to~~ compromise~~d~~ health ~~management~~ outcomes. System challenges include: ~~few~~ suboptimal education and training ~~and educational opportunities for the~~of primary health care practitioners; a fee-for-service payment system ~~model~~ that incentivizes testing and treatments ~~irrespective of their clinical necessity~~over prevention; fragmentation of ~~lack of integration between~~ clinical care and public health service; insufficient continuity of care throughout the entire health care system. Now is an opportune time for China to strengthen the quality of its primary health care as the government is shifting its reform attention to 'improving quality and enhancing efficiency (*ti zhi zeng xiao*, 提质增效)', ~~through implementing an overarching strategy of a learning health system built on digital data and innovative technologies~~. ~~Additionally, the government could also consider t~~The following recommendations merit consideration~~actions~~: enhancement of the quality of training for primary health care physicians and tailor continuing professional development for the current workforce; establishment of performance accountability to incentivize high-quality and high-value care; integration of~~e~~ clinical care with the basic public health services; and strengthening of the coordination between primary health care institutions and hospitals. Additionally, China should consider modernizing its PHC system through the establishment of a learning health system built on digital data and innovative technologies that can combine tools for accountability, efficiency, and improvement. Lessons from these strategies~~These strategies, if successfully implemented,~~ could serve as a model to other countries facing similar challenges.

46

Introduction

As part of China's health care reform effort to provide its citizens with universal and equitable access to high-quality healthcare, primary health care (PHC) has received considerable attention (appendix A~~,~~).[1] This focus is in recognition that the current hospital-centric delivery system is costly and does not serve the changing needs of its ageing population undergoing an epidemiologic transition ~~of its key role in improving population health, economic development, and social harmony~~.[2] China has introduced a number of policies to build PHC-based integrated delivery, and the government has increased its funding to these institutions by more than tenfold, from 19 billion yuan in 2008 to 197 billion yuan in 2018.[3-5] The role of ~~primary health care~~PHC is further reinforced by the Healthy China 2030 Plan announced in 2016,[6] which introduces new directives for health development through prioritizing prevention and primary care.

The effectiveness of these directives hinge on whether China can build a strong PHC system with good quality of care.[7] ~~To strengthen the primary health care system, the government has increased its subsidies to these institutions by more than tenfold, from 19 billion yuan in 2008 to 197 billion yuan in 2018.[3,4] Nevertheless, despite~~ Despite significant financial investment~~,~~ and infrastructure building (appendix B) in the past decade, however, there is evidence that the quality of PHC in China is still suboptimal~~there is evidence that the quality of primary health care is still suboptimal~~, which also contributes to missed opportunities to promote population health and ~~can lead to~~to improve efficiency of service delivery ~~wasted resources and patient dissatisfaction~~.[5,8]

~~[7]~~In this review, we ~~assess~~ summarize the evidence on~~the~~ quality of ~~primary health care~~PHC in China, analyse the causes for poor quality of care~~,~~ and provide policy recommendations for improvement. We adopt the European Primary Care Monitoring System (EPCMS) assessment framework to guide our analyses (panel 2).[9,10] This framework conceptualizes that both structural and process dimensions of a ~~primary health care~~PHC system contribute to three outcomes for ~~primary health care~~PHC: quality, efficiency, and equity. This review focuses on quality because it is essential for improving health outcome

and gaining people's trust. We base our analyses on a literature review (panel 3~~appendix~~) and original data collection through the National Primary Health Care Survey (NPHCS).[11] To develop policy recommendations, we also conducted interviews with key stakeholders, front ~~lines~~ line health workers, and policymakers, as well as evaluations of national and international examples.

Current Quality of China's Primary Health Care

In China, PHC institutions' functions include providing generalist care and implementing the National Basic Public Health Services Program (appendix D).[5] The EPCMS framework specifies nine measures for quality of PHC~~primary health care (panel 2)~~. In this review, we focus on quality of diagnosis and treatment, prescribing behaviour, and quality of chronic disease management, given the rising burden of non-communicable diseases (NCDs) in China and the priorities of its overall health care reform for establishing gatekeeping function of ~~primary health care~~PHC. With respect to other measures covered by the EPCMS, China has already achieved maternal and child health outcomes that approach those of advanced economies,[12] and universal neonatal vaccination was estimated to have prevented 30 million chronic Hepatitis B viral carriers.[13] Unfortunately evidence on quality of mental health care and health promotion in PHC system is not generally available.

Quality of diagnosis and treatment

The quality of the diagnostic process and outcomes was low among PHC~~primary health care~~ providers. A study using incognito standardised patients with common illnesses (dysentery and angina) in the western region showed that village doctors asked patients 18% of the recommended questions and performed 15% of the recommended exams. Doctors addressed ~~Clinicians addressed only~~ 36% of the essential questions or examinations necessary

for a proper diagnosis and to protect patients from harm~~.~~, and correctly diagnosed ~~Only~~ 26% of the ~~village doctors correctly diagnosed the~~ illnesses of these incognito standardised patients.[14]

In another study using incognito standardized patient with classic pulmonary tuberculosis symptoms, correct management proportions at township health centres (38%) and village clinics (28%) were significantly lower than at county hospitals (90%).[15] There is a significant variation of observed doctors' behaviour within each group (township health centres or village clinics) as well,[15] which was similar in other middle-income countries.[16]

Prescribing behaviour

Overuse of antibiotics is common in ~~primary health care~~PHC institutions.[17-19] Systematic reviews showed that the overall weighted average proportion of antibiotic use was over 50% in PHC~~primary health care~~ institutions ~~(appendix)~~,[20] much higher than the standard recommended by WHO (<30%).[21] A 2011 study based on a random sample of PHC institutions in 6 provinces of China also revealed that a quarter of outpatient antibiotics prescriptions and 68% of inpatient antibiotics prescriptions were inappropriate, and improper remuneration incentives was considered a key driver for these prescribing behavior.[22] Moreover, there was a preference of PHC doctors to use broad-spectrum antibiotics,[23] which is deemed quality issue related to professional incompetence,[24] and could induce the emergence and spread of drug-resistant strains of microbes.[24]

Non-communicable diseases like hypertension are largely undertreated.~~Moreover, t~~ The ~~NPHCS~~ largest hypertension survey in China, the NPHCS,~~in 2016~~ found that one third of patients with confirmed hypertension diagnosis took no antihypertensive medication, and 42% took only one medication ~~with~~ and their blood pressure were uncontrolled~~.~~.[25] Meanwhile, it found that approximately 8% of medications used were not ~~guideline~~ guideline-recommended,[26] while high-cost medications were more preferentially used than their counterparts that were evidence-based and ~~low-cost~~cheaper.[26-28] These results suggest

that in addition to medication supply defect, physicians' knowledge of and willingness to adhere to new hypertension treatment guidelines are issues that need to be addressed.[29]

Chronic disease management

With respect to ~~risk factors~~hypertension and diabetes, the most common chronic conditions encountered in PHC settings (appendix E),[5] there is evidence of shortfalls. For ~~example~~hypertension, based on two recent nationally representative ~~surveys~~studies ~~on hypertension management~~,[30,31] the poor awareness (3~~1·9~~2% and 4~~6·9~~7%) and control rates (~~9·7~~10% and 15~~·3~~%) ~~(appendix)~~ indicated gaps in both public health service (i.e. population screening) and clinical care (i.e. patient treatments), as well as poor integration between them in PHC institutions ~~of primary health care providers~~. Under-performance of PHC may explain China's much higher hypertension hospital admission rate (490 per 100 000 population) compared with all OECD countries (average at 95 per 100 000 population).[32,33] Moreover, t~~T~~he poor performance in management ~~and control~~ of hypertension are estimated to lead to compromised health outcomes and tremendous economic losses (panel ~~3~~4).

For diabetes, a nationally representative survey in 2013 of 170,287 Chinese participants found that only 37% of those with diabetes were aware of their diagnosis, and just 32% were being treated.[34] Another nationwide longitudinal survey from 2011 to 2015 identified a decrease in health education coverage (from 76% to 70%) and persisted gaps in use of examinations and treatments (from 79% to 81%), accompanied by an increase in both diabetes-related hospital admission (from 4% to 6%) and readmission (from 19 to 28%).[35] China's diabetes hospital admission rate had reached 260 per 100 000 population,[33] which was much higher than most OECD countries (average at 141 per 100 000 population).[32]

Challenges in Structure and Process of Primary Health Care System

Using the EPCMS framework and drawing on existing literature and expert analyses, we identified two structural (workforce development and remuneration system and income of PHC providers) and two process (coordination of care and continuity of care) dimensions of

China's PHC system as core contributors for gaps in quality of PHC. [29,36]~~Using the EPCMS, we identified structure and process dimensions that are relevant to quality in China's primary health care system, and summarized the recent evidence that contribute to gaps in quality of care, including workforce development and provider remuneration as structure dimensions, as well as coordination and continuity of care as process dimensions.~~

Workforce development

The levels of education and qualification among ~~primary health care~~PHC professionals are ~~historically~~ low. In 2018, 25% of ~~primary health care~~PHC ~~physicians~~ doctors in community health centres and 42% of township health centres had less than junior medical college level of education (the requirement for a licensed assistant physician), which does represent~~s~~ an improvement as the proportions have decreased from 41% and 60% respectively in 2010.[36] Since the nationwide reform of graduate medical education was issued in 2011[37], training for general practitioners (GP), including specific medical school education and in-service training, has been prioritized nationally. The number of qualified GP in China has doubled (from 100 000 to 300 000).[4,38] However, these qualified GPs constituted only a small proportion (from 4% to 13%) of all doctors practicing in China's PHC settings. Moreover, due to a lack of qualified physicians, more than 20% of ~~physicians~~ doctors practicing in community health centres, township health centres, and community health stations were not licensed (appendix H).[5,39] The lack of diverse multidisciplinary primary health care team persisted, as the doctor-nurse ratio is 2.6 compared to 1.5 in the UK,[4] which limits a functional response to the needs of the community.[40]

Substantial gaps exist in the in-service training of ~~primary health care~~PHC professionals. ~~Primary health care~~PHC professionals in China are required to attend and earn a specific number of credits in the Continuing ~~medical~~ Medical ~~education~~ Education~~(CME)~~ programmes annually~~, which aims to help working health professionals keep pace with the development of medical science~~.[41] However, the NPHCS reported that more than a third of physicians, nurses, and public health professionals in ~~primary health care~~PHC institutions

received no Continuing Medical EducationCME training in 2016, with the rate being highest in the Western regions where the socioeconomic development level is the lowest (44·4%).[5] PHC professionals complained that they were too busy to attend trainings, and the trainings failed to meet their needs due to poor contents and unqualified trainers.[42] Furthermore, while there is a plethora of guidelines and consensus statements issued by various academic and professional bodies (e.g. in hypertension there are at least five clinical guidelines and thirteen consensus documents from 14 bodies), the lack of one authoritative, national guidance for each common condition has been an issue in the presence of a relatively poorly trained workforce. In the meantime, clear and consistent guidance on and systematic assessments of safe and effective treatment are often not available in the current system. For example, with respect to hypertension management, there are five relevant clinical guidelines and 13 consensus documents issued by 14 academic institutions in China. This lack of a national standard creates barriers for primary health care professionals to determine which guidance to follow.

Remuneration system and income of primary health care providers

Traditionally, PHC providers (and all other health care providers) in China have been reimbursed via theChina's social health insurance schemes have paid all health care providers, including primary health care institutions, through a fee-for-service payment system model according to a fee schedule set by the government, whether paid by social health insurance or patients' direct out-of-pocket payment. This fee schedule pays diagnostic tests above cost and labour-intensive services (such as consultation) below cost. Providers were also allowed to charge a 15% mark-up for prescription drugs. Social insurance payments are used to cover operating expenses and pay bonuses for staff. This payment system created financial incentives forfee-for-service payment model encourages testing and prescription writing by primary health care providers, irrespective of clinical necessity.[18] Meanwhile, there are few incentives for primary health care institutions or providers to

improve quality of care ~~or to avoid wasteful practices~~. ~~With respect to professionals' income,~~ ~~t~~The NPHCS found ~~demonstrated~~ that payments for ~~primary health care~~PHC physicians do not reward quality and ~~. T~~the bonuses for ~~primary health care~~ PHC physicians that constitute 30% of their income were most often determined by the quantity, rather than the quality of care delivered ~~rather than the quality (i.e. proportion of qualified prescriptions)~~.[5]

~~The fee schedule previously allowed for a 15% mark-up for prescription drugs, which was deemed a major incentive for over-prescribing~~[22]~~.~~ In 2011, the Government introduced the zero-drug mark-up policy, with the aim of removing providers' incentives to over-prescribe~~addressing this issue~~. The removal of drug mark-up was designed to be coupled with a fee schedule adjustment – increasing fees for more labor-intensive services and reducing fees for diagnostic tests – to compensate providers for lost revenue from drugs and to reduce incentives for diagnostic tests. Local governments were expected to increase fiscal subsidies to providers as well. However, largely because of fragmented governance, simultaneous implementation of these polices has proven difficult and evaluation studies find that removal of drug mark-up has had mixed effects on reducing the inappropriate use of drugs, especially antibiotic use.[7] Also, ~~Although well-intentioned,~~ removal of drug mark-up has~~the policy~~ severely affected the revenue of ~~primary health care~~PHC institutions, where more than 50% of the revenue typically comes from drug sales and the provider bonuses depend on drug revenues.[43] Community and township health centres saw a roughly 40% decrease in drug-related incomes since 2011 due to the removal of~~prohibition on~~ drug mark-ups.[44,45] ~~The Government attempted to offset lost drug revenue by subsidising essential drugs, among other measures,~~[46,47]~~but the amount of the subsidies is often much less than the revenue loss,~~[48] ~~and was determined without tying to the quality of care.~~[46] As a result, some ~~primary health care~~PHC institutions apparently made up for their revenue loss by using more intravenous treatment and diagnostic tests, and shifting outpatient care to inpatient care,[53,59] whereas others seek to minimise the amount of clinical care they perform given that there is limited net revenue to be earned. Their lack of willingness to provide clinical care have contributed in some ways to increase in patients presenting at hospitals with minor ailments.[46,47]

Coordination of care

In China, usually PHC providers are not the point of first contact, nor do they coordinate with specialty care. PHC institutions in China provided 53% (4·4 billion) of outpatient care in 2018, which had been declining notably from 62% in 2010,[4,48] despite efforts to strengthen the PHC system in the 2009 health care reform. In a survey covering 17 provinces, the most common reasons that patients bypassed PHC institutions as they need clinical care was poor capacity and skills of the professionals (32%).[49] In a 2013 study, 26% of patients responded that they distrusted community health centres, compared with 6% for hospitals, moreover, patients who knew or have seen doctors at community health centres were more likely to have a negative view of, and an unwillingness to use community health centres.[50] Moreover, as residents of the local community don't seek care at PHC institutions, the ability for PHC institutions to perform public health functions under the National Basic Public Health Service Program could be substantially compromised.

In 2015, the Chinese government issued guidelines for building a "tiered healthcare delivery" system whereby each level of health care facility (tertiary, secondary and primary) would deliver care according to their designated functions,[51] and care across the levels were to be integrated and coordinated with bidirectional referral mechanisms through establishing medical alliance or integrated systems.[52] In spite of some successful pilot experiences in local areas like Shanghai, Shenzhen (Guangdong) and Tianchang (Anhui),[53-55] scaling up of these pilots have been slow and hindered by several factors. First, as hospitals and PHC institutions are still primarily paid by fee-for-service, they compete for patients and have little incentives to coordinate. Second, the social health insurance program, which covers 96% of the population,[4] reimburse patients wherever they seek care without referral, so there is generally no defined coordinating process. In addition, reimbursement for hospital care is more generous than for care at PHC institutions thus incentivising patients to bypass PHC facility, making it difficult for PHC providers to play the gatekeeping function. Third, electronic patient records are not integrated and are seldom shared between PHC institutions and

hospitals.[56] Therefore, even though partnerships between hospitals and PHC institutions are encouraged and have formed in many cities,[57] the association is thus far a loose one.

Within ~~primary health care~~PHC institutions, the National Basic Public Health Service Program could provide a basis for integration between clinical care and public health services. ~~Care coordination is poor between clinical care and public health services. Within primary health care institutions, the National Basic Public Health Service Program could provide a basis for integration between clinical care and public health services.~~ However, the reality was suboptimal for two reasons. First, financing for public health services and clinical care ~~for~~ of the same ~~primary health care~~PHC institutions came from different sources. While the ~~department of finance~~government directly funds a defined package of public health services, clinical care is funded by social health insurance. Second, t~~T~~here is almost no coordination in monitoring, performance measurement, or management between the two programs. Thus, ~~in practice~~ as we observed as both researchers and practitioners, there is little workflow interaction or information sharing between the two. For instance, in hypertension management visits under the National Basic Public Health Service Program, patients can have blood pressure measurement and lifestyle consultations by public health workers, but cannot get antihypertensive prescriptions without attending the clinics. Also, resident health records on public health services and medical records on clinical care are kept by two separate information systems even for the same visit of the same patient and there is no linkage between them. The poor care coordination is a hindrance particularly to managing NCDs. Similarly for infectious diseases like tuberculosis, complete socio-demographic and clinical information on individuals with presumptive tuberculosis cannot be linked across the Infectious Disease Reporting System and the Tuberculosis Information Management System due to the different identification numbers, even both of which were developed by the China Centers for Disease Control and Prevention (CDC), thus analysis on characteristics of individuals who did not complete the referral are not feasible.[58] Finally, since many patients do not seek first contact care (e.g. for acute self-limiting conditions) from PHC institutions,

this severely limits the opportunity of integrating clinical care and public health services.

~~On the one hand, the public lacks confidence in the ability of primary health-care physicians. In the NPHCS, the most common reasons that patients bypassed primary health care institutions as they need clinical care include "do not know them well" (14%), "do not trust them" (13%), and "be not satisfied with their quality of care" (13%).[5,52] In a 2013 nationally representative study, 26% of patients said they distrusted community health centres, compared with 6% for hospitals.[53] Familiarity with health staff and previous experience using services were linked to a negative view of, and an unwillingness to use, community healthcentres.[53]Care coordination is also poor between primary care and secondary care. Bi-directional referral between primary health care institutions and hospitals are yet to be realized in China. Factors that hinder the implementation exist on both demand and supply sides. On the other hand, primary health care providers and hospitals are commonly competing with each other to treat more patients. Primary health care physicians are often reluctant to refer their patients to hospitals, as hospitals rarely refer patients downward since every patient referred downward leads to revenue loss under the fee-for-service payment system.[62]~~

Continuity of care

~~Primary health care~~PHC ~~institutions~~ providers are in a central position to coordinate a person's care needs, from prevention, disease management to curative care~~provide care throughout a person's life course~~. There are several barriers to overcome before this aspiration becomes a reality. ~~, including the absence of patient-centred care. In one observational study, primary health care physicians were observed during the consultation and scored with a checklist on their communication with patients. The findings indicated that in only 2% of the consultations did the physician explore how health problems affected the patients' lives; in only 7% of the encounters was there a check of patients' understanding of~~

~~medical issues; in none of the consultations were educational materials provided; in only 1% did the physician encourage the patient to ask questions.~~[63]

The concept of continuity of care entails several dimensions. First, 'relational continuity' encourages patients to enter into contractual arrangements with family doctors. However, China does not make it compulsory for patients to see ~~primary health care~~PHC providers as their first contact. As the first step towards building a gatekeeping system, the government has introduced a family doctor registration policy by which each resident would be registered with a team of family doctor,[59] however, it is still in an early stage and its potential has yet to be realised. Moreover, there is a general lack of patient awareness about the importance of continuity of care. In a study in Beijing, patients' strong preference for free choice between general practitioners and specialists was not aligned with relational continuity with ~~primary health care~~PHC.[60]

Second, there is inadequate 'informational continuity' throughout the system. The electronic medical record system in ~~primary health care~~PHC institutions is still commonly unavailable, fragmented, and isolated in its ability to integrate and analyse comprehensive information about individual patients.[5] The establishment of the centralised resident health record system in the National Basic Public Health Service Program for the entire catchment populations potentially places ~~primary health care~~PHC services in a position to take a cradle-to-grave approach to managing health care. However, the potential to use these data goes unfulfilled.

Third, with respect to 'managerial continuity', because ~~primary health care~~PHC institutions and hospitals are financed, governed, and managed separately,[61] there are barriers to ensuring consistency, coordination, and quality of care across sites of care. Thus, there are few opportunities for different health care providers to maximise effectiveness of the joint efforts and minimise ~~waste~~ wastage from redundant actions and interventions.

Recommendations for Improvement

To improve the quality of PHC in China, we propose recommendations for addressing the structural and process weaknesses in the system. Overtime, China could ~~primary health care, China needs to~~ modernize its ~~primary health care~~ PHC system through the ~~establishing~~ establishment of a learning platform for evidence generation and training, as well as performance monitoring and promoting.[62] These recommendations could guide China's action plans in terms of policy formulation and designing pilots to test the recommendations' effects and feasibility.~~While the learning platform with linked IT system will provide the structure for care coordination between clinical care and public health service within primary health care institutions and between primary health care providers and hospitals, it needs to be accompanied by a provider payment mechanism and accountability system that enhances care coordination and integration. Furthermore, improved training is required to maintain a stable and competent workforce.~~

~~Build a learning primary health care system~~

~~A learning primary health care system should be data-driven and technology-enabled. It needs a real-time, high-performance IT system that can capture, organise, and normalise data from many sources, maintain data securely, grant access to data selectively, and provide the computational power to rapidly analyse data. The system should be able to produce insights and discoveries about the temporal quality of services, the comparative effectiveness of alternative strategies, and the underlying causal factors for the results being achieved, as well as to make them available to policy makers and researchers. Equally important, the system should ensure that professionals are practicing at the top level of their training and in accordance with the most up-to-date evidence, with the IT support. Specifically, based on integrated data platform, there could be three IT tools that apply innovative technologies for staff training, decision support, and quality control, working in synergy.~~

~~First, in-service training tools that are extended through internet and mobile internet. Online training could be an efficient way to train millions of primary health care professionals in a vast country with wide access to the internet. Such digital learning could potentially~~

facilitate adaptive and personalised courses based on individual abilities. China now has 1·2 billion 4G subscribers with widespread smart phones and other portable terminals,[68] which makes it possible for health care professionals, even in remote rural areas, to leverage their fragmented time to absorb knowledge throughout their careers.

Second, decision support tools that are enhanced by artificial intelligence (AI). The basic function of decision support tools should include recommendations for care based on the latest guidelines and patients' individual characteristics, reminders for dosage adjustments and calculations, alerts for potential contraindications, and prevention of adverse drug reactions. Additionally, AI algorithms can enable these tools to generate new knowledge on efficacy, safety, adherence, and cost-effectiveness of treatments, which still could not be available in traditional trials, with designedly analysing data from the ongoing delivery of care (panel 4).

Third, quality monitoring and feedback tools that are based on big data. Big data technologies can strengthen quality monitoring and feedback in two ways. For quality monitoring, the technologies can facilitate data integration from multiple systems, including electronic medical records, administrative claims, disease surveillance, and death registry, to provide a perspective on a broad array of the process and outcomes of care. For quality feedback, the technologies will enable targeted and timely analysis, with performance benchmarks determined in consideration of not only the literature, but also the local epidemiologic profiles and characteristics of the primary health care setting.

As the basis for applying these tools in identifying the targets, developing the intervention, and assessing the effects, centralised health information systems for primary health care institutions should be put in place to capture and integrate data from everyday practice across China. Cloud-based approaches, which can help users to store and access data and programmes via the internet, and centralised technical support, together with comprehensive registration and classification systems, could be used to avoid fragmentation of standards or challenges in hiring local information technology support, particularly in the coming "5G" era.

China is starting on a strong base in terms of data collection. It is time to turn the data into strategies and actions that would transform care delivery. The Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care form the two core IT systems for everyday primary health care provision in China. The centralised Residents Health Record System was implemented nationwide in 2009 as a part of the National Basic Public Health Service Programme. In 2016, 94% of community health centres and 86% of township health centres had implemented the Residents Health Record System.[5] However, the system has not been fully integrated with the delivery of clinical care, and these health data have rarely been used to facilitate appropriate and efficient clinical practice. With respect to the Electronic Medical Record System, a much wider range of challenges exists. First, the NPHCS found that more than half of community health centres and township health centres had no Electronic Medical Record system. It is probable that the situation was much worse in village clinics. Second, the development and deployment of clinical IT systems in primary health care institutions were highly decentralised, without standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care, second edition (ICPC-2),[69] or protocols to ensure integration and interoperability.[5] Third, only two-fifths of the Electronic Medical Record Systems in community health centres and one fifth in township health centres being linked with hospitals to facilitate patient referrals. These represent opportunities for improvement. The health care system needs an integrated, inter-professional record system per citizen, which can be used both in primary health care institutions and hospital.

Despite China's huge investment and leading position in mobile internet, big data, and artificial intelligence,[70] several concerns have arisen regarding the translation of these technologies into relevant products. First, given the level of education and degree of ageing in Chinese primary health care professionals, who are expected to act as both data generators and users, these tools should be user friendly—the workflow should be optimised and the time it takes to use them should be minimised; the user interface should be intuitive and require minimum training. Second, these tools, particularly the artificial intelligence systems,

~~will need to have transparency regarding how data are managed to engender trust, avoid bias, and guarantee that patients' interests are served. Vendors and users should be committed to ensuring that new strategies are robustly validated and novel tools are adequately tested.~~

Enhance the quality of training for new and current primary health care workforce

The State Council issued the guidance on reform and development of training and incentive mechanisms for ~~primary health care~~PHC physicians ~~has included a comprehensive range of detailed recommendations on the quality of training~~ (appendix I).[63] Despite this ~~promising aspect~~, a comprehensive range of detailed recommendations on the quality of training are needed to address the wide variation in standards of medical school education ~~still needs to be addressed urgently~~. First, t~~T~~he Ministry of Education should consider working closely with the National Health Commission to elevate and ~~closely~~ monitor the quality of training in medical schools and establish accreditation systems. In addition to training qualified PHC physicians, d

~~In the next decade, every medical school should establish a d~~epartments of general practice in medical colleges should also~~. This would serve to~~ develop the academic discipline and nurture the next generation of teachers and leaders, who will drive the agenda of ~~primary health care~~PHC development ~~forward~~ and generate the evidence that is needed to strengthen this field.

~~.~~Second, m~~M~~easures should be implemented to ensure that students attain an appropriate level of clinical competence, and be exposed to ~~primary health care~~PHC ~~from the very beginning of their curricula as well as~~ throughout the training. ~~In addition to clinical competence,~~ Increasingly training should prepare them to work in multi-professional teams, and emphasis should ~~also~~ be placed on the importance of doctor-patient communication, for example, empathy and shared decision-making, in building trust between patients and ~~primary health care~~PHC providers. Third, the government could also consider setting targets for the percentage of medical graduates who would pursue post-graduate training in general

practice,[64] and develop strategies for inspiring students to work in PHC, like exposing undergraduate medical students to PHC and community health service early in the curriculum.[65]

~~In the next decade, every medical school should establish a department of general practice. This would serve to develop the academic discipline and nurture the next generation of teachers and leaders who will drive the agenda of primary health care development forward and generate the evidence that is needed to strengthen this field.~~

In the training for current PHC workforce, ~~For the management of many clinical conditions commonly encountered by primary health care physicians, practical~~ clinical practice guidelines need to be tailored for ~~primary health care~~PHC settings and contain feasible and affordable recommendations, including a patient-centred perspective with integration of patients' goals.[66] These guidelines should focus on the use of cost-effective diagnostic approaches and treatment measures, rather than on, for example, disease aetiology or the pharmacology of medications. China would benefit from a body that oversees the development of disease management protocols, with involvement of ~~primary health care~~PHC providers, which in turn could inform the training of ~~primary health care~~PHC physicians on appropriate and contextualised use. Additionally, incentives would help to motivate PHC doctors to participate the Continuing Medical Education and other in-service training programs, such as providing certifications that are meaningful in their career development and ensuring incomes when they temporarily leave their posts for training.

In addition to doctors, the key role of nurses and other health workers in PHC should be recognized and promoted. Specifically, recent pilot projects on nurse practitioner training, including those that accept new graduates with bachelor degrees from School of Nursing in medical colleges, and others that assign mid-career nurses to practise in PHC institution, could be considered a promising way to strengthen PHC workforce, particularly for chronic diseases management.[67]

Establish performance accountability to incentivize high-quality and high-value care

There is a need for national quality measurement and improvement systems that are linked with incentives to ensure that practices are monitored, outcomes are assessed, and providers are held accountable. Systematic quality improvement requires not only comprehensive indicators, reliable data, and in-depth analysis, but also financial and non-financial incentive mechanisms. These measures need to be timely, accurate and actionable.

Relevant authorities, including the National Health Commission and the National Healthcare Security Administration, could consider strengthening capacity of departments responsible for health-care quality (e.g., the division of medical management in different levels of Health Commissions and national and local Medical Quality Management and Control Centers). The departments could be tasked with monitoring the quality of care provision and provide feedback and support to address gaps in quality.

Social health insurance program's payments to care providers should reward good performance and outcome. Meanwhile publicly available data on care quality could increase accountability, engender trust, and drive improvement. Performance in the management of NCDs such as hypertension is a prime candidate for such initiatives. The newly established National Primary Health Care Hypertension Management Office in China is an example (panel 5).

Integrate clinical care with ~~the~~ basic public health services

China should consider combining the public health budget with the social health insurance budget and shifting the payment of PHC teams from fee-for-service to a capitation payment method.[68] ~~paying primary health care teams by a capitation payment method.~~ The capitation payment rate should be risk adjusted and the rate should cover costs for providing health promotion, prevention, management, and clinical care by the ~~primary health care~~PHC physicians and teams. This will encourage ~~primary health care~~PHC physicians to coordinate

preventive care with clinical care, thereby leading to better management and better outcomes for the patients.

The National Basic Public Health Service Program should consider emphasising that clinical care, including appropriate prescribing of tests and medications, is essential to achieve the goal of health management and disease control. At the national level, in addition to the ~~Centers for Disease Control and Prevention (~~CDC~~)~~, the leading professional institutions ~~for~~ related to the major diseases covered by the National Basic Public Health Service Program could be involved in task definition, guideline development, implementation monitoring, and performance assessment of the services. At the county level, an alliance between the CDC and the county hospital could assume responsibility for the guidance and monitoring of the National Basic Public Health Service Program. At the organisational level, ~~primary health care~~PHC institutions should have full autonomy in personnel and financial management to optimise the resource allocation and payment incentive with the aim to integrate clinical care and basic public health services.

Most performance assessments of ~~primary health care~~PHC institutions examine the quantity of public health services provided, but assessments should also include additional measures of clinical care processes (e.g., availability of basic medications and proportion of appropriate prescriptions) and patient health outcomes (e.g., avoidable hospitalization, incidence of stroke, heart attack, and premature death).

Strengthen the coordination between primary health care institutions and hospitals

To establish a medical alliance or integrated delivery system as encouraged by the State Council of China[69] and recommended globally,[70] ~~primary health care~~PHC institutions and hospitals need to closely coordinate their functions. In addition to vertical technical support provided by hospitals to the ~~primary health care~~PHC institutions within the same catchment areas, deeper coordination between them should be implemented to best suit local contexts (panel ~~5~~6), with integrated systems for staff training, medication supply, health IT support,

equipment procurement, and most importantly, alignment of economic interests~~financial management~~.[71]

To encourage ~~primary health care~~PHC institutions and secondary or tertiary hospitals to coordinate, it is essential to change the provider payment mechanism from one that pays each facility separately, such as by fee-for-service, diagnosis-related-groups, to one that pays according to the size of the population served and the quality of care delivered. ~~focuses on facilities to one that focuses on population.~~ The aforementioned capitation payment methods should cover services at the primary care level as well as the secondary care hospitals, and eventually be extended to cover tertiary care level. The envisioned primary, secondary, and tertiary care team would jointly manage the capitated funds. If there ~~are~~ were savings, they would be shared by the team. This gives incentives for the team to collaborate to invest in prevention and health maintenance and to shift the locus of care to PHC institutions to reduce costs. ~~Since it is less costly to produce the same service at primary health care facilities than it is at hospitals, this would encourage collaborations to strengthen their primary care sectors in the integrated system to encourage more patients to choose primary health care facilities.~~ However, there need to be outcomes assessments to ensure that people are not adversely affected by the rationing of services to increase profit margins.

~~**Establish performance accountability to incentivize high-quality and high-value care**~~

~~There is a need for national quality measurement and improvement systems that are linked with incentives to ensure policies are followed, practices can be monitored, and outcomes can be assessed. Systematic quality improvement requires not only comprehensive indicators, reliable data, and in-depth analysis, but also financial and non-financial incentive mechanisms.~~

~~Relevant authorities, including health authorities and health insurance agencies, could consider strengthening capacity of departments responsible for health care quality (e.g., the division of medical management in different levels of Health Commissions and national and~~

~~local Medical Quality Management and Control Centers). The departments could be tasked with organising appropriate teams that monitor the quality of care provision and provide feedback and support to address gaps in quality.~~

~~Payment to care providers should reward good performance and outcome, meanwhile publicly available data on care quality could increase accountability, engender trust, and drive improvement. Performance in the management of NCDs such as hypertension is a prime candidate for such initiatives. The newly established National Primary Health Care Hypertension Management Office in China has set a good example (panel 6), in which leading professional institutions, with authorisation and strong endorsement from the government, could launch open-minded reform to strengthen quality management.~~

Improve information system towards building a learning primary health care system

An integrated electronic health record system per citizen is needed to improve the quality and efficiency in PHC institutions as well as the entire health care system (panel 7). China should address the challenges in the two core information technology (IT) systems in PHC institutions – the Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care.[5] First, clinical IT systems like Electronic Medical Records should be available in all PHC institutions, including village clinics. Second, the development and deployment of clinical IT systems in PHC institutions need to be centralised, with standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care,[72] to ensure integration and interoperability. Third, the Residents Health Record System that was implemented nationwide in the National Basic Public Health Service Program should be integrated with the delivery of clinical care, to ensure that the health data can be used to facilitate appropriate and efficient clinical practice. Fourth, the Electronic Medical Record Systems in PHC should be linked with the ones used in secondary and tertiary hospitals to facilitate patient referrals.

Over time, China should aim to build a learning PHC system that is data-driven and technology-enabled, with a real-time, high-performance IT system that can capture, organise, and normalise data from many sources, maintain data securely, grant access to data selectively, and provide the computational power to rapidly analyse data. The system should be able to produce insights and discoveries about the temporal quality of services, the comparative effectiveness of alternative strategies, and the underlying causal factors for the results being achieved, as well as to make them available to policy makers and researchers.

Equally important, the system should ensure that professionals are practicing at the top level of their training and in accordance with the most up-to-date evidence, with the IT support. Specifically, based on integrated data platform, there could be three IT tools that apply innovative technologies for staff training, decision support, and quality control, working in synergy.

First, in-service training tools that are extended through internet and mobile internet. Online training could be an efficient way to train millions of PHC professionals in a vast country with wide access to the internet.[73] Such digital learning could potentially facilitate adaptive and personalised courses based on individual abilities. ~~China now has 1·2 billion 4G subscribers with widespread smart phones and other portable terminals,[68] which makes it possible for health care professionals, even in remote rural areas, to leverage their fragmented time to absorb knowledge throughout their careers.~~

Second, decision support tools that are enhanced by artificial intelligence (AI). In addition to t~~T~~he basic function of decision support tools, including ~~should include~~ guideline recommendations ~~for diagnosis and treatment based on the latest guidelines and patients' individual characteristics~~, ~~reminders for~~ dosage calculations ~~adjustments and calculations~~, and~~alerts for potential~~ contraindications alerts~~, and prevention of adverse drug reactions.~~ ~~Additionally~~, AI algorithms can enable these tools to generate new knowledge ~~on efficacy, safety, adherence, and cost-effectiveness of treatments, which still could not be available in traditional trials,~~ with designedly analysing data from the ongoing delivery of care ~~(panel 4)~~.

Third, quality monitoring and feedback tools that are based on big data. ~~For quality monitoring, the~~ T~~t~~echnologies can, on the one hand, facilitate data integration from multiple systems ~~, including electronic medical records, administrative claims, disease surveillance, and death registry~~ in quality monitoring, ~~,~~ to provide a perspective on a broad array of the process and outcomes of care~~. For feedback, the technologies will~~; on the other hand, enable targeted and timely analysis, with performance benchmarks determined in consideration of ~~not only the literature, but also~~ the local epidemiologic profiles and PHC characteristics ~~of the PHC setting~~.

~~As the basis for applying these tools in identifying the targets, developing the intervention, and assessing the effects, centralised health information systems for PHC institutions should be put in place to capture and integrate data from everyday practice across China. Cloud-based approaches, which can help users to store and access data and programmes via the internet, and centralised technical support, together with comprehensive registration and classification systems, could be used to avoid fragmentation of standards or challenges in hiring local information technology support, particularly in the coming "5G" era.~~

Conclusion

During the past decade of health~~-~~ care reform, China prioritised the investment in its ~~primary health care~~PHC system~~, h~~. However, the system is currently facing challenges in providing high-quality and high-value care to the population~~,~~ because of the shortfalls in several dimensions. We suggest a series of recommendations for China to implement or pilot-test with the goal to improve quality of PHC. In time, these would transform China's delivery system from ~~on the corresponding areas. The hope is that the Chinese health-care system would be transformed into~~ one that is hospital-centric to an integrated system anchored in~~primary health care~~ PHC and enabled by the latest technology and data. A strong and high

quality PHC system will help China to achieve the social benefits enshrined in the national Healthy China 2030 strategy. ~~-centric with efficient data-driven and technology-enabled mechanisms continually improving care performance and eliminating wasted resources. Furthermore, now is an opportune time for China to strengthen the quality of its primary health care. If successful, the result of those gains should be reflected in improvement from both health and societal perspectives.~~

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Author Contributions

SH conceived the review and take responsibility for all aspects of it. XL, HMK, and WY designed the study and wrote the first draft.~~,~~ KC and JLu participated in and made critical suggestions for interoperating the findings and generating the recommendations. JDM, QM, EAM, CL, ~~JLu,~~ MS, QZ, DRX, LL, SLN, RP, JLi, ZW, HY, RGa, SC, XG, RGu, HJ, YK, ZP, XW, SX, XX, YZ, JZ, and SZ participated in discussion and provided comments in revision. All authors approved the final version of the Review.

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The authors declared no relevant conflict of interest.

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Panels

Panel 1. Key messages

1. In China, there is evidence of widespread gaps in the quality of primary health care, which leads to suboptimal population health and significant economic impact.
2. The shortfalls of primary health care system include: lack of training and educational opportunities for the practitioners; the fee-for-service model that incentivizes unnecessary testing and treatments; lack of integration between clinical care and public health service, as well as between health care sectors; insufficient continuity of care throughout the entire health care system.
3. ~~The primary health care system should increasingly be configured to be a learning platform for knowledge generation and utilization, which is built on digital data and innovative technologies, particularly for staff training, decision support, and quality control.~~
4. ~~4.~~3. In addition to general practitioner education, China could consider tailoring continuing training for the current primary health care workforce, in which online platform could cover a vast number of professionals and facilitate adaptive programs based on individual abilities.
5. ~~5.~~4. At primary health care level, clinical care and public health services need to be integrated, with respect to provider payment, guideline recommendations, and performance assessment, to bring synergy in disease and health management.
6. ~~6.~~5. ~~The government could encourage c~~Coordination between primary care and hospital care can be incentivized through ~~the~~a population-based capitation payment system ~~method, insurance policy,~~ and an IT platform~~,~~ to match the capabilities of different institutions with the comprehensive needs of the population.
6. China needs performance measurement and accountability in its primary health care system, ~~in which hypertension management could be considered a prime candidate~~

with comprehensive indicators, reliable data, and in-depth analysis, as well as financial and non-financial incentive mechanisms.

7. The primary health care system should increasingly be configured to be a learning platform for knowledge generation and utilization, which is built on digital data and innovative technologies, particularly for staff training, decision support, and quality control.

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939 **Panel 2. European Primary Care Monitoring System: dimensions and features of**

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The European Primary Care Monitoring System was established to assess the primary care comprehensively in 31 European countries. An assessment framework was developed to create a model for holistic analyses of primary care, with relevance, precision, flexibility, and discriminating power. A panel of primary care experts conducted a systematic review of the primary care literature published between 2003 and July 2008, to generate an overview of: 1) the dimensions of primary care; 2) essential features per dimension; 3) applied indicators to measure the features. The resulting framework describes the key dimensions of primary care systems at three levels: structure, process, and outcome level (elaborated in the table below), which was inspired by Donabedian's health system analysis approach.[10]

Primary care dimensions and features

Level	Dimension	Feature
Structure	Governance of the primary care system	1. Health (care) goals; 2. Policy on equity in access; 3. (De)centralization of primary care management and service development; 4. Quality management infrastructure; 5. Appropriate technology in primary care; 6. Patient advocacy; 7. Ownership of primary care practices; 8. Integration of primary care in the health care system.
	Economic conditions of the primary care system	1. Health care expenditure; 2. Primary care expenditures; 3. Health care funding system; 4. Employment status of primary care workforce; 5. Remuneration system of primary care workforces; 6. Income of primary care workforce.
	Primary care workforce development	1. Profile of primary care workforce; 2. Recognition and responsibilities of primary care disciplines; 3. Education and retention; 4. Professional associations; 5. Academic status of primary care disciplines; 6. Future development of primary care workforce.

Process	Access to primary care services	1. Availability of primary care services; 2. Geographic access of primary care services; 3. Accommodation of accessibility (incl. physical access); 4. Affordability of primary care services; 5. Acceptability of primary care; 6. Utilisation of primary care services; 7. Equality in access.
	Continuity of care	1. Longitudinal continuity of care; 2. Informational continuity of care; 3. Relational continuity of care; 4. Management continuity of care.
	Coordination of care	1. Gatekeeping system; 2. Primary care practice and team structure; 3. Skill-mix in primary care; 4. Integration of primary care-secondary care; 5. Integration of primary care and public health.
	Comprehensiveness of primary care	1. Medical equipment available; 2. First contact for common health problems; 3. Treatment and follow-up of diseases; 4. Medical technical procedures and preventive care; 5. Mother/child/reproductive health care; 6. Health promotion.
Outcomes	Quality of primary care	1. Prescribing behaviour of primary care providers; 2. Quality of diagnosis and treatment in primary care; 3. Quality of chronic disease management; 4. Quality of mental health care; 5. Quality of maternal and child health care; 6. Quality of health promotion; 7. Quality of preventive care; 8. Effectiveness; 9. Practice safety.
	Efficiency of primary care	1. Allocative and productive efficiency; 2. Technical efficiency; 3. Efficiency in performance of primary care workforce.
	Equity in health	1. Equity in health.

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Panel 3. Literature search strategy

To summarise the findings of studies on China's primary health care system, we searched the PubMed/Medline and CNKI (China National Knowledge Infrastructure) database in October 2019 (appendix C), to identify relevant studies on seven domains of primary health care (structural, human resources, electronic health record system, financial, insurance, medications, and quality of care) in China. In the PubMed/Medline, we used MeSH and free text terms in conjunction to increase sensitivity to potentially appropriate literature. The MeSH terms include "primary health care", "General Practice", "General Practitioners", "Physicians, Family ", "Community Health Services", "Delivery of Health Care", and terms for each specific domain. Search terms and all their possible synonyms and spellings were identified and used in the search strategy. In the database of CNKI, we used similar strategy to include literature published in Chinese journals.

Panel ~~3~~4. Hypertension control in primary health care, as well as the lifetime health and cost consequences in China

There are more than 270 million patients with hypertension in China.[74] However, in population based studies of hypertension using large samples done after the launch of the programme, nationwide or in specific regions of China,[25,30,31,75-79] increased prevalence, low awareness, low treatment, and poor control of hypertension were found (appendix F), as well as wide variation in the results because of differences in the methodologies (e.g., differences in sampling and age groups included) among studies. Based on two reported national representative surveys, approximately one in four adults had hypertension in the period 2012–25.[30,31] Awareness and treatment rates were unsatisfactory among patients with hypertension, which translated into poor control of blood pressure overall (9·7%[25] and 15·3%[31]).

Poor control of cardiovascular risk factors in the Chinese population could ultimately result in compromised health outcomes. Based on the findings in the largest study on hypertension management in China,[25] we used a state-transition simulation model to predict the lifetime health lost (appendix G).[80] Among 1·7 million Chinese adults aged 35–75 years, gaps in awareness of hypertension result in a total of an estimated 3 336 000 years of life lost and 3 829 000 quality-adjusted life years (QALYs) lost; the treatment gap results in an estimated 6 318 000 years of life lost and 7 251 000 QALYs lost; and the control gap results in an estimated 24 914 000 years of life lost and 28 657 000 QALYs lost.

The suboptimal risk control and lost opportunities to prevent or mitigate disease at the primary care level in China has also had tremendous cost consequences. In the same state-transition simulation mode, the projected costs of antihypertensive drugs, cardiovascular disease event and management, and productivity were predicted from the gaps in hypertension awareness, treatment, and control. It would cost ¥125 million (discounted at 3% per year) per year to fill the awareness gaps, but reaching that scenario would save

¥486 million annually in event costs averted (including both acute and chronic care costs); it would further prevent a discounted productivity loss of ¥2691 million and monetised QALY losses of ¥2609 million per year. Overall, the economic losses due to the gaps in hypertension awareness, treatment, and control would be ¥5661 million, ¥10 722 million, and ¥35 331 million per year.

Categories of economic impact due to gaps in hypertension awareness, treatment, and control (per year, in millions of 2015 yuan)

	Awareness gap	Treatment gap	Control gap
Decreased antihypertensive drug cost	151	286	1 029
Decreased antihypertensive drug cost (discounted)	125	237	854
Increased cardiovascular disease event cost	548	1 039	3 085
Increased cardiovascular disease event cost (discounted)	486	920	2 725
Productivity loss	3 064	5 802	18 230
Productivity loss (discounted)	2 691	5 097	15 938
Monetized discounted quality-adjusted life years lost	2 609	4 942	17 521
Total economic loss	5 661	10 722	35 331

Panel 4. A clinical trial on learning decision support tools in primary health care institutions

The LIGHT (Learning Implementation of Guideline based decision support system for Hypertension Treatment) trial, sponsored by the China National Center for Cardiovascular Diseases, presents an example of an innovative solution to the insufficient amount of evidence in hypertensive management in primary care practice.

The main trial is primarily designed to evaluate the efficacy of a decision support system compared with the usual care for appropriate control of hypertension in a cluster randomized trial at institution level. The duration of the main trial will be 12 months after site randomization.

Among the sites using the decision support system (i.e. the intervention group), there is an embedded randomized trial, at patient level, to assess the efficacy of different drug regimens for the control of blood pressure. Within the decision support system in this trial, an algorithm not only provided recommendations on evidence-based medication, but also randomly allocated patients with hypertension to different treatment protocols that are equally recommended by up-to-date guidelines to compare their real-world effectiveness. Specifically, eligible participants will be randomized to receive one of the protocols initiated with following monotherapies: angiotensin-converting enzyme inhibitor or angiotensin receptor blocker (A), calcium channel blocker (C), or diuretic (D), or the protocols initiated with two-drug combination therapy AC, AD, or CD. B will be added for the individuals with heart rate>80 beats/min. The enrolled patients for this trial will be followed up for 9 months for outcome measurement.

Treatment algorithms could improve by learning from the results of such comparisons. Similarly, one can also compare generic versions of the same medication from different manufacturers. Such information could inform medication procurement by the government and prescribing by primary health care providers.

Panel 5. How has Shenzhen been reforming its primary health care system?

Shenzhen, a megacity in Southern China, is globally known for its rapid economic development and technological innovation. The average life expectancy for its 13 million permanent residents is 81 years, similar to that of the United Kingdom. There are 686 community health centres in Shenzhen, which provided 27·5 million clinical visits (about 30% in total) in 2017. Since 2016, the municipal government of Shenzhen has implemented a series of policies to strengthen its primary health care system by establishing primary care groups, which are networks of integrated management, shared responsibilities, and common interests.

Integrated Management

To set up tight Medical Alliances (医联体), the Shenzhen municipal government has established a primary care group, as independent legal entities in each district, to integrate distribution of medical resources, care delivery, and information utilization in primary health care institutions and hospitals. As the core of a primary care group, the tertiary general hospital has full autonomy in personnel and financial management of all the public community health centres within.

Health care professionals working in community health centres are employed by primary care groups and share the same salary standards and social insurance packages with their counterparts working in hospitals. Moreover, physicians in primary health care institutions have extra benefits compared with their counterparts in hospitals, including special subsidies from the government and more opportunities for technical post promotion.

Similar to physicians in tertiary and secondary hospitals, doctors in community health centres can prescribe any medication in the social medical insurance medication list issued by the government, including 48 antihypertensive drugs and 15 antidiabetic drugs.

~~Meanwhile, medication availability is ensured by the unified delivery system covering both community health centres and hospitals throughout the city.~~

~~Primary care groups use the unified electronic health record system to ensure that information is interoperable across institutions. In addition, three databases at the municipal level have been consolidated to inform health care management, including the electronic medical records across all levels of clinical care, digital health records with basic public health documents for every resident, and population records with vital registration and demographic information of the entire population.~~

~~Shared Responsibilities~~

~~The primary care groups are responsible for the full range of clinical care needs of local residents, whereas tertiary hospitals mainly provide emergency and inpatient care and community health centres handle common clinical visits and basic public health services. In order to quickly strengthen the diagnosis and treatment capabilities of community health centres, a new pattern of tests in community health centres, diagnosed by the group based on telemedicine services within the primary care group, has been introduced and validated. In addition, the prescriptions from each community health centre are centrally reviewed by the pharmacist team in the local secondary hospitals.~~

~~Each individual resident has a contracted family doctor team that consists of specialists from tertiary hospitals and primary health care physicians from community health centres who are collectively expected to provide comprehensive and continuing care. Thus, establishing networks of teams has been a central function of primary care groups and a focus of health policies. Other sections of the health care system, including public health agencies and nursing institutions, are also now participating in the routine work of teams.~~

~~Several policies have been implemented to tighten the connections between members of the primary care group in care delivery. Public hospitals have established specialty clinics in 432 (60%) local community health centres, which have significantly improved the~~

~~accessibility and quality of clinical care at the community level, with the price of services 20% lower than in tertiary hospitals and the health insurance reimbursement rates 30% higher. Also, patients referred from community health centres have priority in outpatient visits, clinical tests, and hospital admissions in the hospitals, which has greatly promoted coordination within primary care groups.~~

~~Common Interests~~

~~The government of Shenzhen has implemented a needs-based capitation approach in social health insurance reimbursement, accompanied with differentiate pricing policies, to incentivize primary care groups to save costs. Each patient's annual capitation paid the providers by the government is mainly determined by his/her total health insurance payment during the last year. If the actual reimbursement amount this year is smaller than the capitation, the surplus can be kept by the patient's contracted primary care group. As a result, in the primary care groups, hospitals and community health centres have been collaborating to develop and implement strategies that save cost through, for example, containing outpatient visits to the community health centres where the price of services is 20% lower than in hospitals, prioritizing risk control and disease prevention, or reducing unnecessary use of advanced facilities. Meanwhile, patients are also incentivized to go to community health centres, since their out-of-pocket payment there (about 10% of the total cost) could be substantially reduced compared with what they would pay at hospitals (about 30% of the total cost) due to higher insurance coverage and lower price of services.~~

~~In the wake of the zero drug mark-up policy, the municipal Health Commission intends to incentivize health care providers to actively meet the clinical needs of the population via a subsidy system for medical services. Hospitals and community health centres can receive a 30 yuan subsidy from the government for each outpatient visit, regardless of the actual charge during the visit. Thus, the mechanism encourages physicians to deliver more services, rather than to prescribe more testing or drugs. Since 2017, the subsidy for~~

~~community health centres has increased to 40 yuan per outpatient visit, so that the primary care groups are shifting their focus of outpatient care from hospitals to community health centres within.~~

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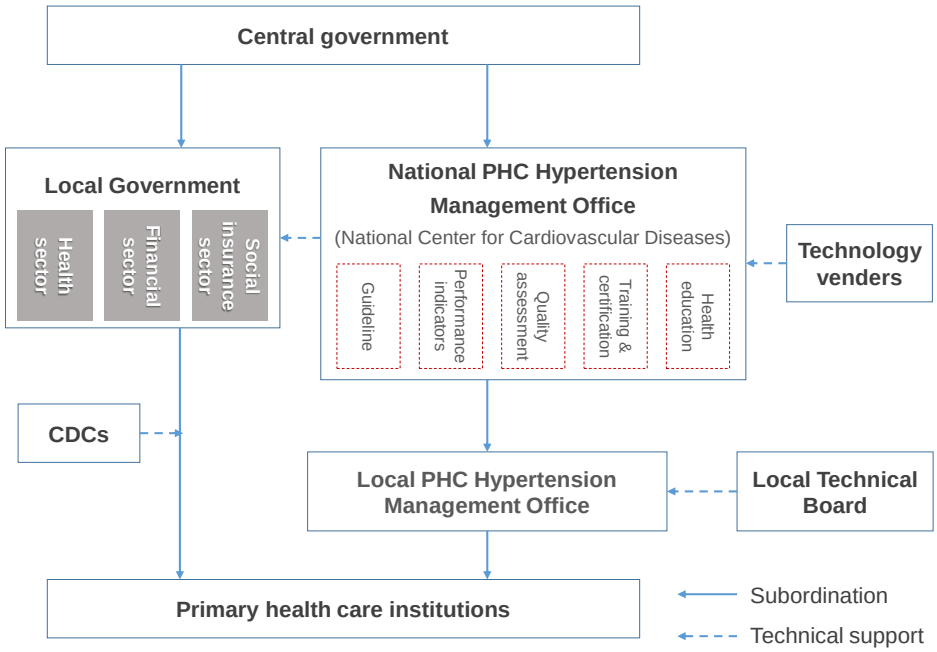
Panel ~~6~~5. A national initiative on improving ~~hypertension management through~~ primary health care – the National Primary Health Care Hypertension Management Office

~~In the health care reform of 2009, the National Basic Public Health Service Program was initiated, with hypertension management at primary health care institutions as one of the pillars under sponsorship from the government.[86] Nevertheless, barriers at the policy level (omission of quality measurement), organization level (lack of qualified staff, limited availability of antihypertensive drugs), physician level (irrational prescribing), and patient level (low health literacy) all contribute to low disease control across China.[5,25,26]~~

~~Therefore, as a national initiative, the National Health and Family Planning Commission (now the National Health Commission) authorized the National Center for Cardiovascular Diseases to establish t~~The National Primary Health Care Hypertension Management Office was established in March 2017 with the ~~. The main~~ charge ~~of the Office was~~ to develop strategies and practices ~~ways~~ to improve hypertension management nationwide and to serve as a model for other services in the program (see figure below).



New model for primary health care hypertension management in China

CDC: Center for Disease Control and Prevention

In practice, the Office developed five key strategies ~~specifically for the primary health care system, initiating the implementation in Yunnan Province and then uniformly throughout China. These strategies are~~: 1) a new clinical practice guideline; 2) a set of performance indicators; 3) a quality assessment system; 4) training and certification mechanisms; and 5) health education platforms.

Clinical practice guideline

With significant input from clinical and public health opinion leaders, WHO experts, policymakers, and representatives of primary care professionals, the guideline was developed with the premise that optimal primary health care must satisfy four key elements: it must be evidence-based, streamlined, practical, and affordable ~~(appendix)~~. To facilitate the application, a toolkit was released to provide a visual representation of the

clinical pathway. In addition to clinical recommendations, the guideline also states the regulatory requirements and assessment indicators for primary health care hypertension management teams.[81]

Performance indicators

Eight indicators for disease management were included: 1) evidence-based prescription rate; 2) blood pressure control rate; 3) standard follow-up rate; 4) incidence of cardiovascular events, such as stroke and myocardial infarction; 5) staff success rate in completing the training program; 6) availability of antihypertensive medications; 7) standard management rate; and 8) patients' compliance to hypertension treatment.

Quality assessment data collection system

Key information of hypertension diagnosis, treatment, and prognosis is entered in real time at the baseline and follow-up visits at primary health care institutions through a customized developed electronic data collection system ~~(appendix)~~. Periodical reports based on a predefined analysis plan are generated automatically and sent to various users including policymakers and institution managers.

Physician training and certification platform

A comprehensive free-of-charge platform (Yun-que, Xiong-ying, and Qun-yan) that provides both online and offline training sessions was established in Jan 2018. Within 1 year, more than 1·51 million physicians from 0·34 million primary health care institutions nationwide~~located in all 31 provinces~~ registered for the Yun-que online training program, 0·78 million of whom were certified after successful completion. Through the use of health IT, personalized training modules are developed based on the evidence of strengths and weaknesses in practice. The Xiong-ying and Qun-yan programs have also held 27 offline training sessions, and trained more than 2000 individuals to assist practicing physicians.

Health education platform

The Office developed a bank of health education messages using behavioural change techniques applicable to the Chinese cultural context and compatible with Chinese beliefs and values. Primary care professionals can receive messages periodically from the bank through an application on their computers or smart phones, and push the messages to the most relevant persons (e.g., smoking cessation counselling for smokers), using short messages, or via Instant Messenger and social networks.

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963 **Panel 6. How has Shenzhen been reforming its primary health care system?**

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Similar to physicians in tertiary and secondary hospitals, doctors in community health centres can prescribe any medication in the social medical insurance medication list issued by the government, including 48 antihypertensive drugs and 15 antidiabetic drugs. Meanwhile, medication availability is ensured by the unified delivery system covering both community health centres and hospitals throughout the city.

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Shared Responsibilities

The primary care groups are responsible for the full range of clinical care needs of local residents, whereas tertiary hospitals mainly provide emergency and inpatient care and community health centres handle common clinical visits and basic public health services. In order to quickly strengthen the diagnosis and treatment capabilities of community health centres, a new pattern of tests in community health centres, diagnosed by the group based on telemedicine services within the primary care group, has been introduced and validated. In addition, the prescriptions from each community health centre are centrally reviewed by the pharmacist team in the local secondary hospitals.

Each individual resident has a contracted family doctor team that consists of specialists from tertiary hospitals and primary health care physicians from community health centres who are collectively expected to provide comprehensive and continuing care. Thus, establishing networks of teams has been a central function of primary care groups and a focus of health policies. Other sections of the health care system, including public health agencies and nursing institutions, are also now participating in the routine work of teams.

Several policies have been implemented to tighten the connections between members of the primary care group in care delivery. Public hospitals have established specialty clinics in 432 (60%) local community health centres, which have significantly improved the accessibility and quality of clinical care at the community level, with the price of services 20% lower than in tertiary hospitals and the health insurance reimbursement rates 30%

higher. Also, patients referred from community health centres have priority in outpatient visits, clinical tests, and hospital admissions in the hospitals, which has greatly promoted coordination within primary care groups.

Common Interests

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In the wake of the zero drug mark-up policy, the municipal Health Commission intends to incentivize health care providers to actively meet the clinical needs of the population via a subsidy system for medical services. Hospitals and community health centres can receive a 30-yuan subsidy from the government for each outpatient visit, regardless of the actual charge during the visit. Thus, the mechanism encourages physicians to deliver more services, rather than to prescribe more testing or drugs. Since 2017, the subsidy for community health centres has increased to 40 yuan per outpatient visit, so that the primary

care groups are shifting their focus of outpatient care from hospitals to community health centres within.

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Panel 7. Integrated National Electronic Health Records: experiences on information technology for primary health care in Finland

In Finland, each of the 5·3 million citizens has a Personal Health Record, which is integrated into a national repository known as the eArchive. These together provide a centralized location for patients, health care providers, pharmacies, and social workers to keep track of patient information, communicate with each another, and make informed clinical decisions. Each patient is listed under a primary health care institution that takes full responsibility for the patient's integrated care, and patients have control over which social workers and health care professionals have access to their information. All patients have secure access to their own records over the Internet using their bank account credentials, mobile identity verification, or an electronic identity card. Patients use the system to fill prescriptions and update their health information in their Personal Health Records with home measurements including blood pressure, peak expiratory flow, blood glucose, diet, and exercise. Electronic communication between professionals and patients is supported by symptom checkers and follow-up forms, secured messages, or real-time chat.

The care is linked to decision-support tools (e.g., guidelines of the most frequent problems encountered in primary health care) and also artificial intelligence that can help practitioners implement guidelines (e.g., the system checks if a medication prescribed by the family physician is compatible with the renal function of the patient and if not, proposes alternatives). In cases of referral, the information in the Personal Health Record is accessible by the specialist providers.

Appendix

A. Phases of development of primary health care in China

Since the establishment of the People's Republic of China in 1949, its primary health care system has gone through three major phases.

From the 1950s to the 1970s

China received global recognition for its achievements in health improvement and health system development. Its success was particularly notable in the rural areas, where overall health status improved in a relatively short period despite extremely scarce resources. The three-tiered health care delivery system, so-called "barefoot doctors" at village clinics, and low-cost universal health insurance (cooperative medical scheme) were considered the three key elements of its success. The three-tiered health care delivery system in rural areas comprises the clearly defined and well-operated functions of three levels of health providers and organization at the village, township, and county level. In parallel, a similar health care delivery structure was developed in urban areas comprised of three levels of health organizations at the street (now called community), district, and municipal level. China's strategy of focusing on the provision of preventive care and basic curative care at an affordable cost (through insurance coverage and low-cost services) was considered a model of health system development, and the country was intensively involved in the development of the 1978 Alma-Ata Declaration. Core primary health care concepts and policies within the Declaration, including full governmental support, accountability for health, inter-sectorial cooperation on health, affordable health care, education, and a comprehensive development system, were derived from China's successful experiences. The context within which China developed its health system was similar to that of many low-income countries, which was a key factor in the acceptance of the Chinese primary health care model by other developing countries when designing their own health systems.

From the 1980s to the early 2000s

The Chinese primary health care system faced challenges as a result of the central government reducing its role in health care financing and insurance organization. Insurance coverage rates under the cooperative medical scheme decreased from 95% in 1976 to 5% in 1985.[82] After several failed attempts to raise funds for health care, the Ministry of Health began emphasizing the importance of self-reliance, and it pursued alternative funding through market-oriented reform.[83] The integrated three-tiered health care delivery system was dismantled as health providers at the village level became privatized, while township-level and county-level hospitals/health centres became self-financing. Preventive care was phased out in favour of the higher revenues provided by curative care. Moreover, hospitals grew in number and scope of services, attracting an increasing number of patients in this competition with the primary health care system.[4,36] Thus the prior advantage in health care efficiency of China, in comparison with other countries with similar levels of development, was gradually losing. Rural health centres, in particular, experienced enormous difficulty under the market-oriented reforms. As the primary health care institutions deteriorated and relied on revenue from user fees, the public health functions of these facilities greatly diminished. During this time, China was widely criticized by both national and international academic and health care organizations for its inability to extend primary health care coverage to all. In its 2000 annual report, WHO ranked China at the bottom fourth of its 191 member states in terms of equitable financial health protection.[84]

From the early 2000s to the present

A policy report commented that "China's health care reform since 1978 was in general a failure".[85] This report, combined with public complaints about health care, were the driving forces behind a new phase of system reform. The government began to re-establish the rural health insurance system in 2003 and the urban resident health insurance system in 2007. A more comprehensive reform agenda, developed by a number of line ministries with technical support from academic institutions, was implemented in 2009. Since then, strong primary health care has been a key strategy of health care reform in addition to universal health insurance coverage, a National Essential Medicines System, and basic public health services. The government increased its subsidies to primary health care institutions from 19 billion RMB in 2008 to 197 billion RMB in 2018.[3,4] Acknowledging the increasing pressure exerted by an aging population, behavioural changes,[86] and rapid urbanization,[87] the Healthy China

2030 plan issued in 2016 envisions the primary health care system as a means of addressing the emerging dual burden of chronic NCDs and increasing health expenditures.[88]

B. Institutions providing primary health care in China

In 2015, the Chinese State Council issued the Plan for the Health Care Delivery System (2015–2020), in which various health care organisations and their functions were defined.[51] The primary health care system in China is divided into urban and rural components, each with a two-tier structure. Most of the institutions in this system are publicly owned (ie, the institutions are owned by all or a specific group of Chinese citizens).[4,36] In 2018, urban components included approximately 9300 community health centres and, one level below them, 25 600 community health stations. Rural components included approximately 36 400 township health centres and, one level below them, 622 000 village clinics.[4]

In addition to the four types of care institutions above, there are about 228 000 community clinics (96% privately owned), 21 600 clinics belonging to individual organisations such as schools and companies (34% privately owned),[36] and many community pharmacies (most privately owned). The community clinics mainly provide medical care in specific fields such as dental disorders or traditional Chinese medicine (TCM). The clinics belonging to organisations provide health care services only to employees or students of the organisation. These clinics and pharmacies are important parts of clinical care delivery, as they supplement the primary health care system. Moreover, a growing number of private health management companies scattered in large cities are providing medical examination, disease screening, and outpatient services too.

~~A.~~C. Method of literature searching

We searched the PubMed/Medline ~~(1966-2017)~~ and CNKI (China National Knowledge Infrastructure) database in ~~July~~ October 2019~~2016~~, to identify relevant studies on seven domains of primary health care (structural, human resources, electronic health record system, financial, insurance, medications, and quality of care) in China. ~~In the PubMed/Medline (1966-2017), we used MeSH and free text terms in conjunction to increase sensitivity to potentially appropriate literature. The MeSH terms include "primary health care", "General Practice", "General Practitioners", "Physicians, Family ", "Community Health Services", "Delivery of Health Care", and terms for each specific domain.~~ Search terms and all their possible synonyms and spellings were identified and used in the search strategy (Table A-1). In the database of CNKI, we used similar strategy to include literature published in Chinese journals (Table A-1).

Table A-1 English literature from PubMed/Medline

Search topic	Query	Items found
EHR system	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Electronic Health Records"[Mesh] OR “Hospital Information Systems"[Mesh] OR "information technology"[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	~~26~~58
Medications	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family"[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND ("Drugs, Essential"[Mesh] OR “Medication Systems"[Mesh] OR “Medicine, Chinese Traditional”[Mesh]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	~~434~~534
Quality	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township	~~767~~10294

Search topic	Query	Items found
	health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Health Services Accessibility"[Mesh] OR “Healthcare Disparities"[Mesh] OR “Practice Patterns, Physicians'"[Mesh] OR “Practice Patterns, Nurses'"[Mesh] OR “Professional-Patient Relations"[Mesh] OR “Health Services Research"[Mesh] OR “Quality of Health Care"[Mesh] OR "quality"[Title/Abstract] OR "performance"[Title/Abstract]OR behaviour [Title/Abstract] OR behaviors [Title/Abstract] OR behaviour [Title/Abstract] OR behaviours [Title/Abstract] OR "disparities"[Title/Abstract] OR "disparity"[Title/Abstract] OR "gap"[Title/Abstract] OR "gaps"[Title/Abstract] OR "measure"[Title/Abstract] OR "measurements"[Title/Abstract] OR "adherence"[Title/Abstract] OR Inequity[Title/Abstract] OR equity[Title/Abstract] OR inefficiency[Title/Abstract] OR efficiency[Title/Abstract] OR efficient[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	
Human resources	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“manpower"[Mesh] OR “Education, Public Health Professional"[Mesh] OR “Education, Professional"[Mesh] OR “Education, Medical, Continuing"[Mesh] OR “Professionalism"[Mesh] OR “Career Choice"[Mesh] OR “Career Mobility"[Mesh] OR "human resources"[Title/Abstract] OR "retention"[Title/Abstract] OR "incentives"[Title/Abstract] OR "salary"[Title/Abstract] OR "professional medical master"[Title/Abstract] OR Motivation[Mesh] OR “Salaries and Fringe Benefits”[Mesh] OR “Staff Development”[Mesh] OR “Inservice Training”[Mesh] OR “Training Support”[Mesh] OR “Physician Incentive Plans”[Mesh] OR “Employee Incentive Plans”[Mesh] OR “Personnel Management”[Mesh] OR “Health Resources”[Mesh] OR incentive[Title/Abstract] OR motivation[Title/Abstract] OR motivations[Title/Abstract] OR motivating[Title/Abstract] OR salaries[Title/Abstract] OR income[Title/Abstract] OR wage[Title/Abstract] OR wages[Title/Abstract] OR "financial reward"[Title/Abstract] OR "financial rewards"[Title/Abstract] OR "fringe benefit"[Title/Abstract] OR "fringe benefits"[Title/Abstract] OR train[Title/Abstract] OR training[Title/Abstract] OR trainings[Title/Abstract] OR scholarship[Title/Abstract] OR scholarships[Title/Abstract] OR education[Title/Abstract] OR educational[Title/Abstract] OR "career development"[Title/Abstract] OR "development opportunity"[Title/Abstract] OR "development opportunities"[Title/Abstract] OR "resource availability"[Title/Abstract] OR "resources availability"[Title/Abstract] OR "working condition"[Title/Abstract] OR "working conditions"[Title/Abstract] OR "work condition"[Title/Abstract] OR "work conditions"[Title/Abstract] OR "working environment"[Title/Abstract] OR "working environments"[Title/Abstract] OR "work environment"[Title/Abstract] OR "work environments"[Title/Abstract] OR "human resource management"[Title/Abstract] OR "human resources management"[Title/Abstract] OR "personnel management"[Title/Abstract] OR “Personnel Turnover”[Mesh] OR “Emigration and Immigration”[Mesh] OR Personnel Loyalty[Mesh] OR “Professional Practice Location”[Mesh] OR attraction[Title/Abstract] OR attracting[Title/Abstract] OR attract[Title/Abstract] OR attracted[Title/Abstract] OR attracts[Title/Abstract] OR retaining[Title/Abstract] OR retain[Title/Abstract] OR retained[Title/Abstract] OR retains[Title/Abstract] OR recruitment[Title/Abstract] OR recruiting[Title/Abstract] OR recruit[Title/Abstract] OR recruited[Title/Abstract] OR recruits[Title/Abstract] OR migration[Title/Abstract] OR migrate[Title/Abstract] OR migrating[Title/Abstract] OR migrated[Title/Abstract] OR migrates[Title/Abstract] OR immigration[Title/Abstract] OR immigrate[Title/Abstract] OR immigrating[Title/Abstract] OR immigrated[Title/Abstract] OR immigrates[Title/Abstract] OR emigration[Title/Abstract] OR emigrate[Title/Abstract] OR emigrating[Title/Abstract] OR emigrated[Title/Abstract] OR emigrates[Title/Abstract] OR mobility[Title/Abstract] OR turnover[Title/Abstract] OR "brain drain"[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT	~~4557~~6040

Search topic	Query	Items found
	“News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	
Insurance	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Insurance, Health"[Mesh] OR “out-of-pocket”[Title/Abstract] OR “New Rural Cooperative”[Title/Abstract] OR affordability[Title/Abstract] OR affordable[Title/Abstract] OR catastrophic[Title/Abstract] OR "urban resident basic medical insurance"[Title/Abstract] OR "cooperative medical scheme "[Title/Abstract] OR "NCMS"[Title/Abstract] OR “financial protection”[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	~~422~~647
Financial	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract]) AND (“Healthcare Financing"[Mesh] OR “Remuneration"[Mesh] OR “Capital Financing"[Mesh] OR "Health Resources"[Mesh] OR “Resource Allocation"[Mesh] OR payment[Title/Abstract] OR subsidy[Title/Abstract] OR subsidies[Title/Abstract] OR budget[Title/Abstract] OR fund[Title/Abstract] OR resource[Title/Abstract] OR resources[Title/Abstract] OR resourcing[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary Materials”[ptyp] NOT “Festschrift”[ptyp] NOT “Interactive Tutorial”[ptyp] NOT “Legal Cases”[ptyp] NOT “Letter”[ptyp] NOT “News”[ptyp] NOT “Patient Education Handout”[ptyp] NOT “Periodical Index”[ptyp] NOT “Personal Narratives”[ptyp] NOT “Portraits”[ptyp] NOT “Published Erratum”[ptyp] NOT “Retracted Publication”[ptyp] NOT “Retraction of Publication”[ptyp] NOT “Twin Study”[ptyp] NOT “Video-Audio Media”[ptyp] NOT “Webcasts”[ptyp]	~~1110~~1540
Structural	Search (China[Title/Abstract] OR Chinese[Title/Abstract]) AND ("primary health care"[Mesh] OR "General Practice"[Mesh] OR "General Practitioners"[Mesh] OR "Physicians, Family "[Mesh] OR "Community Health Services"[Mesh] OR "Delivery of Health Care"[Mesh] OR "township hospital"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centre"[Title/Abstract] OR "township health centres"[Title/Abstract] OR "township health centres"[Title/Abstract] OR "community health station"[Title/Abstract] OR "village clinic"[Title/Abstract] OR "village clinics"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centre"[Title/Abstract] OR "community health centres"[Title/Abstract] OR "community health centres"[Title/Abstract]) AND (“Organization and Administration"[Mesh] OR “Health Policy"[Mesh] OR “Organizational Policy"[Mesh] OR “Referral and Consultation"[Mesh] OR “gatekeeping"[Mesh] OR gatekeeper[Title/Abstract] OR governance[Title/Abstract] OR reform[Title/Abstract] OR referral[Title/Abstract] OR “integrated health care”[Title/Abstract] OR “three tier health care system”[Title/Abstract]) AND ((eng[Language]) OR chi[Language]) NOT “Autobiography”[ptyp] NOT “Bibliography”[ptyp] NOT “Biography”[ptyp] NOT “Consensus Development Conference”[ptyp] NOT “Consensus Development Conference, NIH”[ptyp] NOT “Corrected and Republished Article”[ptyp] NOT “Dataset”[ptyp] NOT “Dictionary”[ptyp] NOT “Directory”[ptyp] NOT “Duplicate Publication”[ptyp] NOT “Electronic Supplementary	~~2435~~3276

Search topic	Query	Items found
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Table A-2 Chinese literature from Chinese National Knowledge Infrastructure (CNKI)

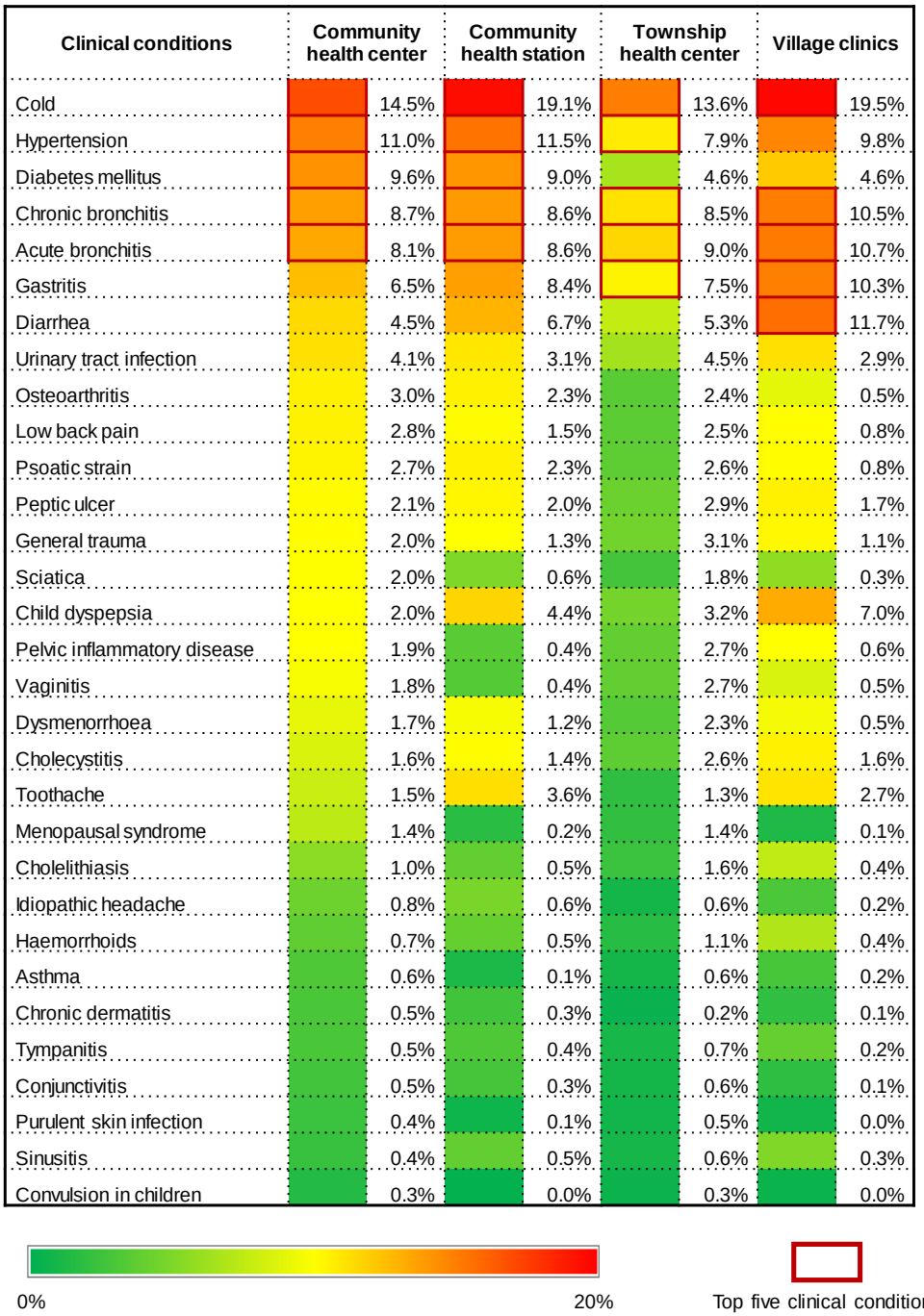
Search topic	Query	Items found
Structural	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='组织'+'框架'+'结构'+'改革'+'转诊'+'协同'+'配合'+'分工'+'分级诊疗'	Journal articles: 415~~158~~ Doctoral thesis: 4 Master thesis: 62~~41~~
Financial	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='经费'+'资金'+'财政'+'支出'+'收入'+'收支'+'补偿'+'拨款'+'拨付'+'药品零差'	Journal articles: 133~~87~~ Doctoral thesis: 4 Master thesis: 19
Insurance	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='医保'+'保险'+'自付'+'报销'+'新农合'+'新型农村合作医疗'+'封顶'+'起付'+'拨款'+'拨付'+'药品零差'+'救助'	Journal articles: 63~~49~~ Doctoral thesis: 2 Master thesis: ~~15~~16
Human resources	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='人力资源'+'人员流动'+'薪酬'+'激励'+'职业发展'+'职业规划'+'培训'+'技能'+'人员能力'+'教育'+'轮转' AND HX=Y	Journal articles: ~~129~~161 Doctoral thesis: 3 Master thesis: 59
Quality	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND AB='医疗质量'+'服务质量'+'患者满意'+'用药合理性'+'合理用药'+'医疗安全'+'服务效率'+'依从性'+'循证'+'同质'+'医疗可及性'+'服务可及性'	Journal articles: 699~~190~~ Doctoral thesis: 3~~7~~3 Master thesis: ~~207~~304
EHR system	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='信息系统'+'电子病历'+'信息技术'+'数据'+'健康档案'	Journal articles: 88~~33~~ Doctoral thesis: 1 Master thesis: 21~~13~~

Search topic	Query	Items found
Medications	TI='基层卫生'+'基层医疗'+'初级卫生'+'社区医疗'+'社区卫生'+'乡村医疗'+'乡村卫生' AND TI='基本药物'+'基药'+'药品供应'+'药品零差'+'药品加成'+'药品定价'+'药政'+'药品管理'	Journal articles: ~~78~~153 Doctoral thesis: 2 Master thesis: ~~31~~36

~~B.~~D. Evolution of the National Basic Public Health Service Program

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Funding, Yuan per capita	15	15	25	25	30	35	40	45	50
Residents' health records	√	√	√	√	√	√	√	√	√
Health education	√	√	√	√	√	√	√	√	√
Child health management	√	√	√	√	√	√	√	√	√
Maternal health care	√	√	√	√	√	√	√	√	√
Elderly health management	√	√	√	√	√	√	√	√	√
Vaccination	√	√	√	√	√	√	√	√	√
Reporting of infectious diseases and public health emergencies	√	√	√	√	√	√	√	√	√
Health management for hypertension	√	√	√	√	√	√	√	√	√
Health management for type-2 diabetes	√	√	√	√	√	√	√	√	√
Health management for psychosis	√	√	√	√	√	√	√	√	√
Health supervision	–	–	√	√	√	√	√	√	√
Traditional Chinese medicine health management	–	–	–	–	√	√	√	√	√
Health management for tuberculosis	–	–	–	–	–	–	√	√	√
Contraceptive device	–	–	–	–	–	–	–	–	√
Health promotion	–	–	–	–	–	–	–	–	√

E. The scope of the clinical care provided in primary health care institutions in China



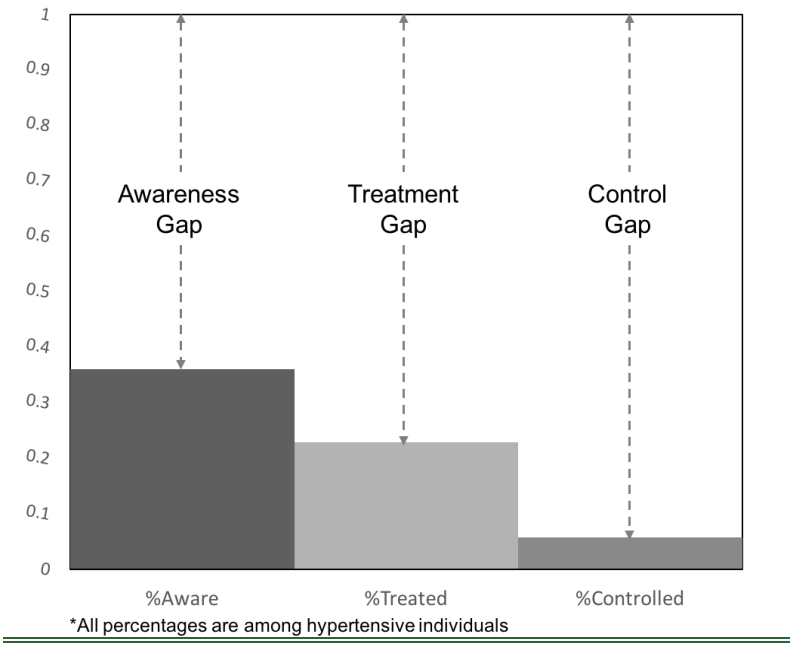
To understand the scope of the clinical care provided in primary health care institutions in China, we asked the 10,626 primary health care physicians and village doctors involved in our survey to identify the top five clinical conditions that they encounter in regular practice. In community health centres and community health stations, the most commonly identified conditions were common cold (14·5% and 19·1%, respectively), followed by hypertension (11·0% and 11·5%), diabetes (9·6% and 9·0%), chronic bronchitis (8·7% and 8·6%), and acute bronchitis (8·1% and 8·6%). Doctors at township health centres and village clinics identified common cold (13·6% and 19·5%, respectively), acute bronchitis (9·0% and 10·7%), and chronic bronchitis (8·5% and 10·5); however, they more often identified

gastritis (7·5% and 10·3%) and diarrhea (5·3% and 11·7%) than hypertension (7·9% and 9·8%) and diabetes (4·6% and 4·6%).

~~C.A. Lifetime health and cost consequences prediction based on a state-transition simulation model~~

~~We used a state-transition simulation model to predict the lifetime health and cost consequences of cardiovascular disease (CVD) and hypertension in the 1.7 million individuals in the China Patient-centred Evaluative Assessment of Cardiac Events (China PEACE). Specific outcomes include life expectancy, Quality-adjusted Life Years (QALYs), antihypertensive drug cost, CVD event cost, chronic CVD management cost, and productivity. The projected health and economic effects are rescaled and age- and gender- standardized to represent the entire Chinese population aged 35 to 75 years.~~

~~In the model, we simulated four scenarios for different proportions of hypertension awareness, treatment and control: 1) Current, 2) All-aware, 3) All-treated, and 4) All-controlled. The "all-aware" scenario assumes that all hypertensive individuals are diagnosed but the diagnosed individuals are only proportionally treated and controlled; the "all-treated" scenario assumes that all hypertensive individuals are treated but the treated individuals are only proportionally controlled (based on the treatment and control proportions in the current scenario); and the "all-controlled" scenario assumes that all hypertensive individuals are controlled. Therefore, the "awareness gap" is defined as the gap between the all-aware scenario and the current scenario; the "treatment gap" is defined as the gap between the all-treated scenario and the current scenario; and the "control gap" is defined as the gap between the all-controlled scenario and the current scenario (see the figure below).~~



Appropriateness of prescriptions in primary health care institutions in China (Jan 2009 through Jul 2016)

Study	Design	Study period	Regions	Types of institutions	No. of sites	No. of prescriptions	Indicators	Major findings
Dong, et al. 2011 [95]	Observational	2005	10 provinces in the Western regions	Village clinics	680	20 125	Proportion of antibiotic prescriptions	48·43%
							Average number of drugs per prescription	2·36
							Proportion of injected drug	22·93%
Liu, et al. 2009 [96]	Observational	2007	26 provinces in the Eastern, Central and Western regions	Community health centres and community health stations	744	74 400	Average number of drugs per prescription	2·51
							Proportion of antibiotic prescriptions	43·58% (12·30% two or more antibiotics)
							Proportion of injected drug	35·11%
Li, 2015 [97]	Observational	2009-2013	1 province in the Eastern regions	Community health centres and community health stations	1 207	Unspecified	Proportion of injected drug	54·53%to 13·66%
							Proportion of two or more antibiotics	27·23% to 5·64%
Ding, 2010 [98]	Observational	2009	1 province in the Eastern regions	Community health centres	12	1 106	Proportion of injected drug	28·5%
							Proportion of antibiotic prescriptions	43·3% (18·4% two or more antibiotics)
Ying, et al. 2010 [99]	Observational	2007-2008	1 province in the Eastern regions	Community health centres, community health stations, township health centres, village clinics	97	7 737	Proportion of two or more antibiotics	17% to 26%
							Proportion of injected drug	35% to 51%
Zhao, et al. 2012 [100]	Observational	2009-2011	1 province in the Central regions	Primary health care centres	5	1 454	Proportion of injected drug	42·07% (pre-EDL) vs. 43·63% (post-EDL)
							Proportion of antibiotic prescriptions	54·55% (pre-EDL) vs. 65·65% (post-EDL) (12·47% vs. 22·43% two or more antibiotics)
							Average number of drugs per prescription	2·78 (pre-EDL) vs. 3·30% (post-EDL)

Study	Design	Study period	Regions	Types of institutions	No. of sites	No. of prescriptions	Indicators	Major findings
Jia. et al. 2015 [101]	Observational	2013	1 province in the Eastern regions	Community health centres	13	380	Average number of drugs per prescription	2·95 (pre-EDL) vs. 2·51 (post-EDL)
							Proportion of antibiotic prescriptions	28·9% (pre-EDL) vs. 41·0% (post-EDL)
							Proportion of injected drug	30·0% (pre-EDL) vs. 43·0% (post-EDL)
Qi. et al. 2012 [102]	Observational	2007	1 province in the Eastern regions	Township health centres	5	11 177	Proportion of injected drug	61·5%
							Average number of drugs per prescription	4·1
							Proportion of antibiotic prescriptions	35·1%
Song. et al. 2014 [103]	Observational	2010-2011	4 provinces in the Eastern and Central regions	Township health centres	146	28 651	Average number of drugs per prescription	3·64 to 3·46
							Proportion of antibiotic prescriptions	60·26% to 58·48%
							Proportion of injected drug	40·31%
Wang. et al. 2014 [22]	Observational	2009-2011	6 provinces in the Eastern or Central regions	Urban and rural primary health care centres	39	7 311	Average number of drugs per prescription	2·7
							Proportion of injected drug	64·30%
							Proportion of antibiotic prescriptions	52·90%
Xiao. et al. 2011 [104]	Observational	2007	2 provinces in the Eastern and Western regions	Community health centres and township health centres	20	22 356	Average number of drugs per prescription	3·1
							Proportion of two or more antibiotics	24·90%
Liu. et al. 2015 [105]	Interventional	2013	1 province in the Central regions	Primary health care institutions	10	336 655	Proportion of antibiotic prescriptions	65% to 60% (22% to 20% two or more antibiotics)
							Proportion of injected drug	60% to 55%
Yao. et al. 2015 [106]	Observational	2009-2010	1 province in the Central regions	Community health centres and township health centres	192	23 040	Average number of drugs per prescription	3·5 (pre-EDL) vs. 4·2 (post-EDL)
							Proportion of antibiotic prescriptions	62% (pre-EDL) vs. 67% (post-EDL)

Study	Design	Study period	Regions	Types of institutions	No. of sites	No. of prescriptions	Indicators	Major findings
							Proportion of injected drug	45% (pre-EDL) vs. 52% (post-EDL)
Gong. et al. 2016 [107]	Observational	2007-2011	35 cities in the Eastern, Central and Western regions	Community health centres and community health stations	802	376 700	Average number of drugs per prescription	2·3 (EDL) vs. 2·5 (non-EDL)
							Proportion of antibiotic prescriptions	38% (EDL) vs. 48% (non-EDL) (8% vs. 12% two or more antibiotics)
							Proportion of injected drug	31% (EDL) vs. 40% (non-EDL)
Yang. et al. 2013 [108]	Observational	2009-2011	1 province in the Central regions	Community health centres and township health centres	18	55 800	Average number of drugs per prescription	3·4 to 4·7, vs. 4·1 in cohort 1-3
							Proportion of antibiotic prescriptions	53% to 75%
							Proportion of injected drug	59% to 67%, vs. 67%, 66% and 59% in cohort 1-3
Yin. et al. 2015 [109]	Observational	2011	35 cities in the Eastern, Central and Western regions	Community health centres	422	42 200	Average number of drugs per prescription	2·24 (public) vs. 2·38 (private)
							Proportion of antibiotic prescriptions	30·1% (public) vs. 37·2 (private)
							Proportion of injected drug	30·5% (public) vs. 36·4 (private)
Yip. et al. 2014 [19]	Interventional	2009-2012	1 province in the Western regions	Township health centres and village clinics	294	1 155 134	Proportion of antibiotic prescriptions	44·2% (control group) vs. 37·6% (intervention group) in township health centres; 34·2% (control group) vs. 28·2% (intervention group) in village clinics
Xiao. et al. 2016 [110]	Observational	2009-2012	2 provinces in the Central regions	Township health centres	24	7 311	Proportion of antibiotic prescriptions	52·50% to 53·41%
Jiang. et al. 2012 [111]	Observational	2007	1 province in the Western regions	Township health centres	30	3 059	Proportion of antibiotic prescriptions	85·18% (24·98% two or more antibiotics)
	Observational	2013			20	Unspecified	Proportion of antibiotic prescriptions	62%

Study	Design	Study period	Regions	Types of institutions	No. of sites	No. of prescriptions	Indicators	Major findings
Zhang. et al. 2014 [112]			1 province in the Central regions	Township health centres			Proportion of injected drug	65%

~~D.~~F. Prevalence, awareness, treatment, and control rates of hypertension from large-sample population studies after 2009

Study	Year of study	Population (years)	Sampling	Number of sites	Sample size	Prevalence (%)			Awareness (%)			Treatment (%)			Control (%)		
						Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Wang ZW, et al. 2018 [31]	2012 - 2015	≥18	Stratified multistage random sampling	262 (city level) from 31 provinces	451 755	23·2	23·1	23·4	46·9	44·7	50·9	40·7	38	45·8	15·3	13·1	19·4
Lu JP, et al. 2017 [25]	2014 - 2017	35-75	Convenience sampling	141 (county level) from 31 provinces	1 738 886	44·7	46·1	42·5	44·7	43·8	46·3	30·1	28·2	33·4	7·2	6·1	9·1
Li YC, et al. 2016 [30]	2013 - 2014	> 18	Stratified multistage random sampling	605 (county level) from 31 provinces	174 621	27·8	31·6	32·3	31·9	20·1	32·5	26·4	14·9	26·8	9·7	5·5	10·1
Yang L, et al. 2016 [76]	2013	≥15	Stratified multistage random sampling	10 (city level) from Zhejiang province	19 254	24·6	25·2	24·1	67·4	64·7	70·2	55·8	53·3	58·2	30·8	26·2	35·4
Fan L, et al. 2014 [79]	2012	15-74	Stratified multistage cluster sampling	30 (county level) from Henan province	18 772	26·6	NA	NA	46·0	NA	NA	35·7	NA	NA	10·4	NA	NA
Yin MH, et al. 2016 [77]	2011 - 2012	≥ 45	Four-stage stratified cluster sampling	150 (county level) from 28 provinces	13 583	41·7	NA	NA	57·9	NA	NA	46·4	NA	NA	23·4	NA	NA
Bi ZQ, et al. 2014 [75]	2011	18-69	Four-stage cluster sampling	20 (county level) from Shandong province	14 230	23·4	24·6	20·8	34·5	31·4	42·9	27·5	24·6	35·6	14·9	13·9	17·7

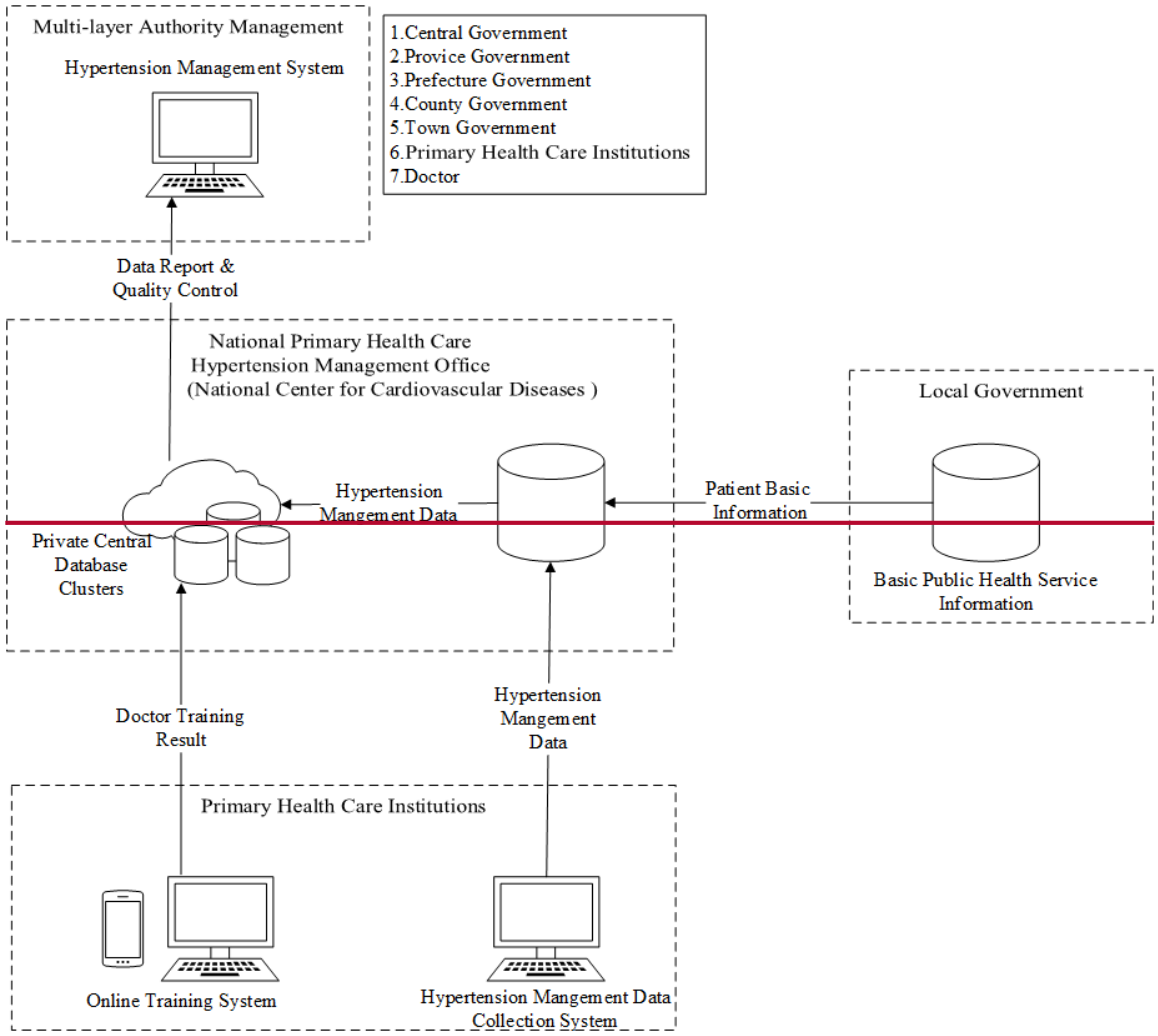
NA: not available.

Information technology systems for primary health care hypertension management

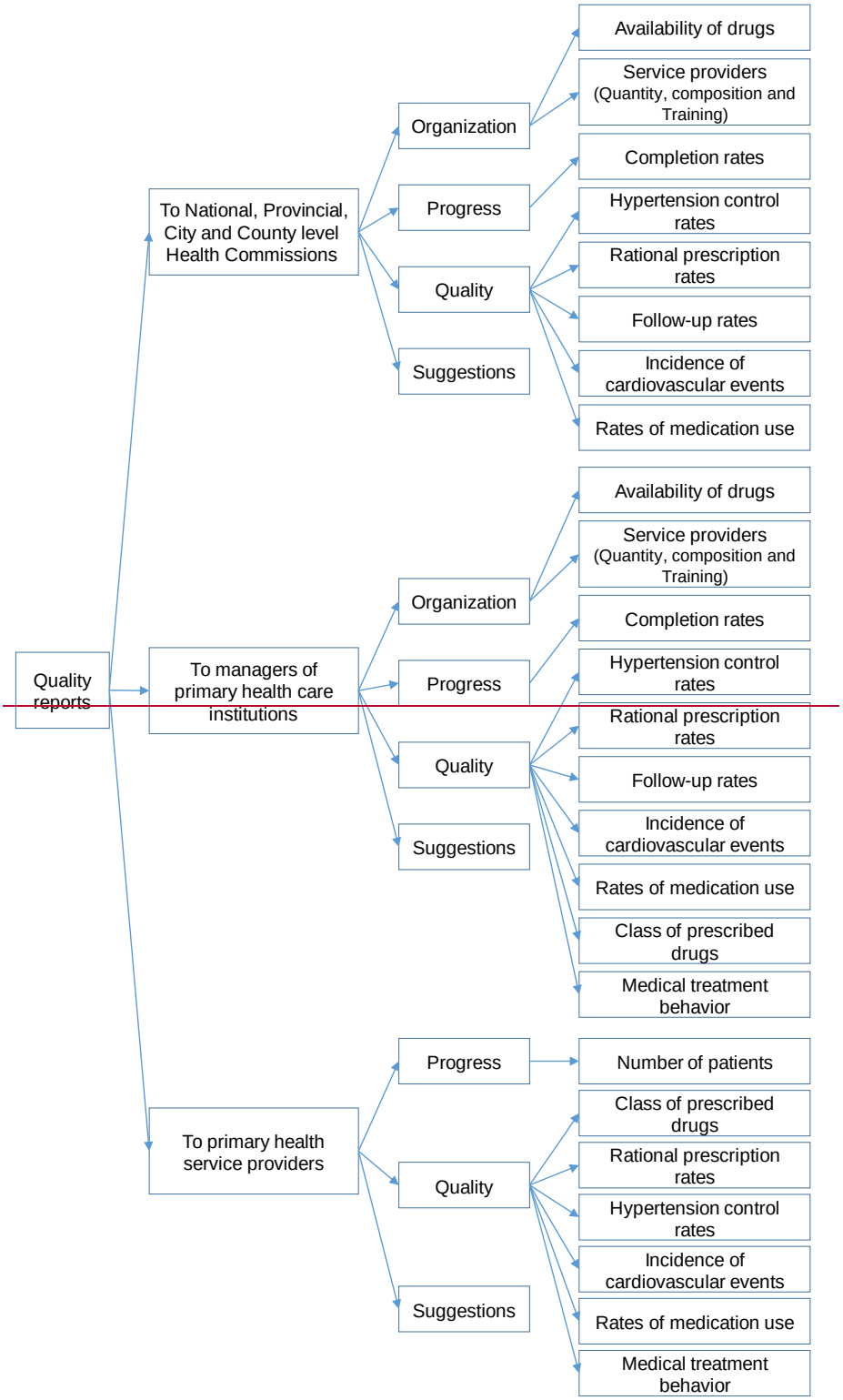
Data collected on hypertension management visit in primary health care institutions

(1) Past medical history (for the first visit only) / new diagnosed co-morbidities (from the follow-up visits: myocardial infarction, heart failure, stroke, diabetes, chronic kidney disease, etc.)
(2) Physical examination: systolic blood pressure/ diastolic blood pressure, heart rate, height, weight and waist
(3) Smoking: current smoker or not
(4) Tests: (routine blood and urine test, serum potassium, serum creatinine, ECG etc.)
(5) Current medications: antihypertensive drugs, antiplatelet drugs, lipid regulating drugs
(6) Diagnosis: (hypertension, diabetes, coronary heart disease, etc.)
(7) Lifestyle change intervention
(8) Prescription: antihypertension drugs, antiplatelet drugs, lipid regulating drugs

System structure and data flow



~~Periodical quality reports to authorities and primary health care providers~~



National Clinical Practice Guidelines on the Management of Hypertension in Primary Health Care (2017)

Preparation of the Guidelines

Purpose of Preparation

It is estimated that nearly 270 000 000 people in China are hypertensive. Serious complications of hypertension, including stroke, coronary heart disease, heart failure, and kidney disease, result in high rates of disability and mortality, significantly burdening patients' families and society. However, hypertension is preventable and controllable. Studies indicate that antihypertensive therapy can reduce the risk of stroke by 35–40%, the risk of myocardial infarction by 20–25% and the risk of heart failure by more than 50%. Therefore, prevention and control of hypertension are the core strategies for decreasing the prevalence of cardiovascular and cerebrovascular diseases in China.

Primary health care institutions (e.g., community health service centers, community health service stations, township health centers, and village clinics) are the main "battlefield" for hypertension management, and the management of hypertension at the primary care level directly influences the trends in cardiovascular and cerebrovascular diseases in China. Successful management of hypertensive patients as part of the National Essential Public Health Service Program is intended to increase the rate of blood pressure (BP) control, prevent or delay complications of hypertension, and ultimately lower mortality and improve quality of life. With the goal of satisfying the information needs of primary medical workers and effectively supporting hypertension management at the primary health care level, experts organized by the National Essential Public Health Service Program's Office for Management of Hypertension in Primary Health Care, established by the National Center for Cardiovascular Diseases under the entrustment of the Department of Primary Health Care of the National Health and Family Planning Commission, have prepared these Guidelines.

Principles of Preparation

In preparing these Guidelines, feasibility, traceability, and measurability of management effects were key considerations. Simple and practical therapeutic regimens that can be mastered by primary medical workers are provided. Drug therapy recommendations are based on concrete medical evidence in order to gradually homogenize hypertension management at the primary health care and hospital levels.

Scope of Preparation

These Guidelines are intended for medical workers in primary health care institutions. The targeted patient population includes hypertensive adult patients aged ≥18 years within the administrative region of each primary health care institution. The Guidelines focus on the basic requirements for the management of hypertension in primary health care, including the management flow, diagnostic procedures, therapeutic regimens, and long-term management requirements. To further support the diagnosis and appropriate treatment of hypertension by primary care workers, the National Manual for Management of Hypertension in Primary Health Care (hereinafter referred to as "Manual") will be referenced. This Manual provides detailed information on the recommendations given in these Guidelines, along with supporting clinical evidence.

Process of Preparation

The main references of these Guidelines are Guidelines for the prevention and treatment of hypertension in China (2010); Guidelines for the management of hypertension in PHC in China (2014); Guidelines for the management of hypertension in the community; 2014 evidence-based Guideline for the management of high blood pressure in adults (JNC8); The seventh report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure (JNC7); 2013 ESH/ESC Guidelines for the management of arterial hypertension; Clinical management of primary hypertension in adults (NICE, 2011); Hypertension Canada's 2016 Canadian Hypertension Education Program Guidelines for blood pressure measurement, diagnosis, assessment of risk, prevention, and treatment of hypertension; Guidelines on prevention and treatment of dyslipidemia in Chinese adults (2016). The Guidelines considers the requirement both from the National Health and Family Planning Commission and the primary health care doctors, reviewed and finalized by the National Committee on Hypertension management in PHC. Hope these Guidelines could be used widely in PHC, and the national hypertension office in PHC would like to ask for feedback continuously to make it better in the future.

Abbreviations

ACEI: angiotensin-converting enzyme inhibitor
ALT: alanine transaminase
ARB: angiotensin II receptor blocker
BP: blood pressure
CCB: calcium channel blocker
DBP: diastolic blood pressure
ECG: electrocardiogram
HDL-C: high-density lipoprotein cholesterol
LDL-C: low-density lipoprotein cholesterol
PHC: primary health care
SBP: systolic blood pressure
TC: total cholesterol
UCG: urine chorionic gonadotropin

General Recommendations for the Management of Hypertension in Primary Health Care

Establishment of hypertension management teams

Primary health care institutions should establish hypertension management teams composed of physicians, nurses, and public health workers to provide standardized services to hypertensive patients, in accordance with the recommendations in these Guidelines and under institutional leadership. Physicians serving on the teams should be trained and qualified by the appropriate unified national examinations.

Supply of basic equipment

Sphygmomanometers: Certified upper-arm electronic sphygmomanometers are recommended; traditional desk-model mercurial sphygmomanometers are also acceptable. Sphygmomanometers should be periodically calibrated. Use of wrist-type or finger-type sphygmomanometers is not recommended.

Additional equipment that should be available at all primary health care institutions: body height and weight scales, tape measures for waist circumference, equipment for routine blood and urine tests, electrocardiogram (ECG) monitors, and biochemical analyzers. Periodic calibration is required.

If possible, primary health care institutions may also be equipped with ambulatory BP monitors, cardiac ultrasound machines (including color Doppler), chest X-ray machines, and fundus examination apparatus.

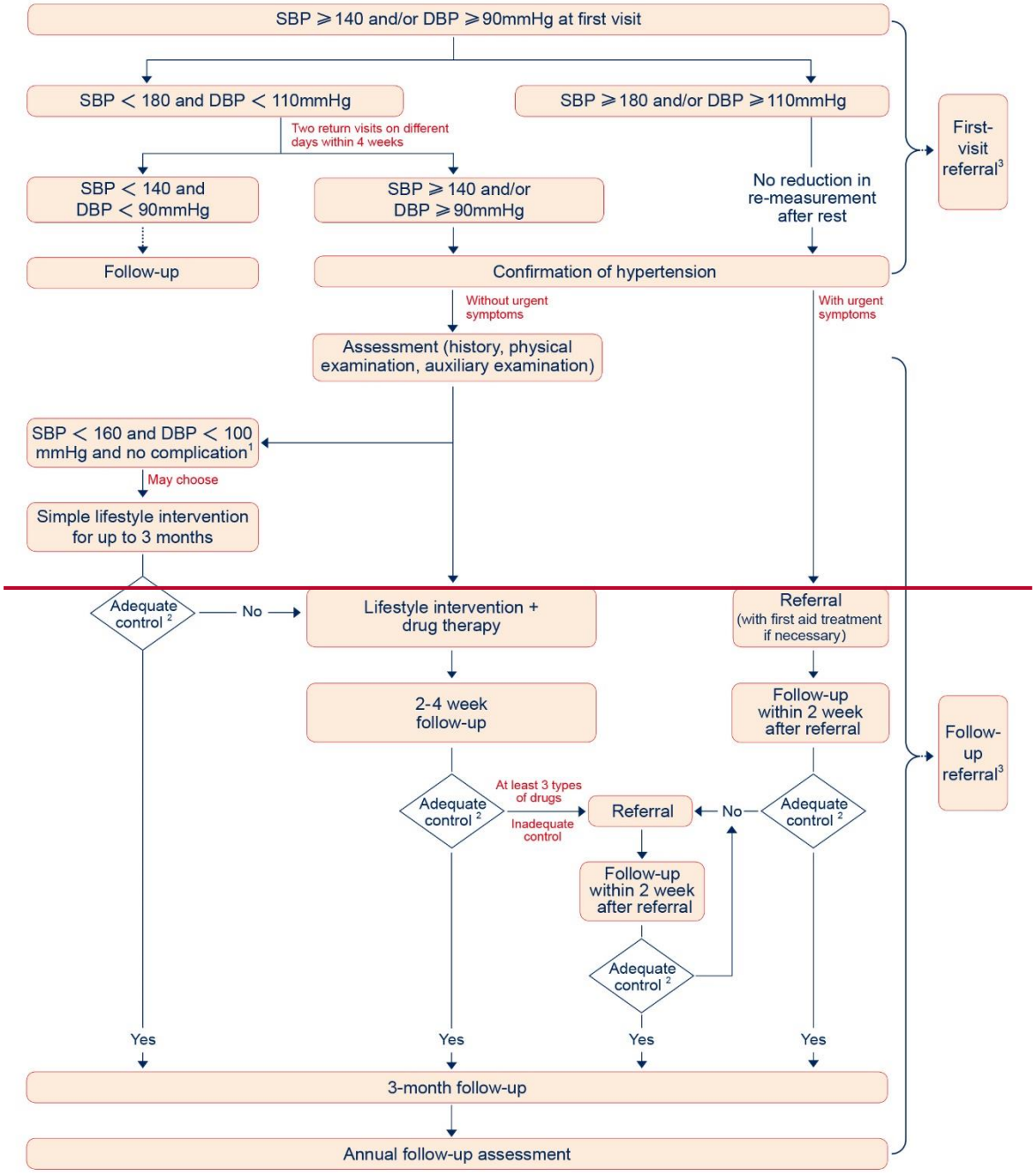
Essential drugs

Primary health care institutions should have the following classes of antihypertensive drugs:

A: Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin II receptor blockers (ARBs). These drugs have similar mechanisms and at least one type should be available.
B: β-receptor blockers.
C: Calcium channel blockers (CCBs). In particular, dihydropyridine CCBs are commonly used for lowering BP.
D: Diuretics. In particular, thiazide diuretics are commonly used for lowering BP.

Management flow of hypertension in primary health care

Primary health care institutions should undertake diagnosis, treatment, and long-term follow-up of patients with primary hypertension. Furthermore, hypertensive patients who are not suitable for diagnosis and treatment in primary health care institutions should be referred in a timely manner. The goal of management is to adequately lower BP and reduce the risk of complications. See the figure below for the detailed management flow.



Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure.

[1]Complications include coronary heart disease, heart failure, stroke, chronic kidney disease, diabetes mellitus or peripheral atherosclerosis.

[2] Adequate control among general hypertensive patients is defined as SBP <140 mmHg and DBP <90 mmHg. Patients with concomitant chronic kidney disease or diabetes mellitus are encouraged to a bit lower than the general goal if appropriate. Among patients aged ≥65 years, adequate control is defined as SBP <150 mmHg and DBP <90 mmHg, and if it is tolerable, SBP<140mmHg is encouraged for patients aged 65 to 80 years.

[3] See P15 for referral indications.

Highlights of Diagnosis and Treatment

1. Three essentials of blood pressure measurement: **rest and relaxation, standardized position, accurate reading**
2. Essentials of diagnosis: **diagnosis based primarily on the office blood pressure measurement using 140/90 mmHg as the cutoff value, diagnosis confirmation if three measurements on different days are all above normal**
3. Six components of a healthy lifestyle: **salt restriction, weight loss, exercise, smoking abstinence, alcohol restriction, peaceful mood**
4. Three principles of treatment: **adequate control, stabilization, comprehensive management**
5. Four populations needing hypertension referral: **acute onset, severe symptoms, suspected secondary hypertension, refractory hypertension**

Diagnosis of Hypertension

I. Blood pressure measurement

(I) Measurement setting

1. Office BP: Definitive diagnosis of hypertension in primary health care institutions should be primarily based on office BP measurements.

2. Home BP: Home BP measurements are a primary means of patient self-management and can be used for auxiliary diagnosis (see Manual for home BP measurement methods).

3. Ambulatory BP monitoring: Where appropriate, such monitoring may be adopted as a basis for auxiliary diagnosis and drug therapy adjustment in primary health care institutions.

(II) Measurement instruments

1. Certified upper arm electronic sphygmomanometers or desk-model mercurial sphygmomanometers complying with standards should be used. Periodic calibration is required.

2. The cuff size should be chosen based on the patient's upper-arm circumference, with the bladder of the cuff covering at least 80% of the circumference. Cuffs are commonly 22-26 cm long and 12 cm wide; a larger cuff should be used for patients with greater upper arm circumferences.

(III) Measurement method

The three essential elements of standardized measurement are rest and relaxation, standardized position, and accurate reading.

Rest and relaxation: The patient should avoid any possible influencing factors (e.g., avoid smoking or drinking tea or coffee for at least 30 min and empty bladder before measurement) and rest quietly for at least 5 min prior to measurement. During measurement, the patient should be seated with feet placed on the ground and instructed to relax and not talk.

Standardized position: The middle of the upper arm cuff should be level with the heart (i.e., at nipple level; the mercurial sphygmomanometer should also be level with the heart). The lower margin of the cuff should be 2-3 cm (about the width of two fingers) above the cubital fossa and appropriately tight to allow insertion of 1 to 2 fingers. When a desk-model mercurial sphygmomanometer is used, the chest piece of the stethoscope should be placed where the brachial pulse is strongest and must not be bound in the cuff.

Accurate reading: When an electronic sphygmomanometer is used, directly read and record the displayed systolic BP (SBP) and diastolic BP (DBP) values. When a mercurial sphygmomanometer is used, the first sound and the disappearance sound (in case of no disappearance, the significantly weakening tune-change sound) during deflation correspond to the SBP and DBP, respectively. Look horizontally at the top of the liquid convex surface of the mercurial column and record the BP to the nearest 2 mmHg. Avoid approximation by rounding to values ending with 0 or 5 (e.g., do not round 142/94 mmHg to 140/95 mmHg).

Notes:

(1) Measure BP of both upper arms at the first visit and, in the future, regularly measure the BP of the side with the highest reading. If the difference between the measurements for the two upper arms is >20 mmHg, referral should be made to exclude secondary hypertension.

(2) To make the diagnosis of hypertension, BP should be measured 3 times in different day. And each time BP should be measured a minimum of 3 times at intervals of 1-2 minutes; the lower value (mainly considers SBP) of the last two readings should be recorded as the patient's BP.

(3) In each clinic measurements after diagnosis, BP should be measured a minimum of two times at intervals of 1-2 minutes if SBP $\geqslant$140mmHg and DBP $\geqslant$90mmHg; the lower value (mainly considers SBP) of the last two readings should be recorded as the patient's BP.

II. Diagnostic criteria

1. Office BP should be used as the primary basis for making a diagnosis:
If SBP is $\geq$140 mmHg and/or DBP is $\geq$90 mmHg at the first visit, two additional measurements within 4 weeks are recommended. A diagnosis can be confirmed if the diagnostic cut-off is reached during 3 measurements on different days.

If SBP is ≥180 mmHg and/or DBP is ≥110 mmHg at the first visit, immediate referral is suggested for patients with acute symptoms. For patients without overt symptoms, other possible causes should be excluded. If the criteria are still met after the patient has rested quietly, a diagnosis can be confirmed, and drug therapy should be immediately administered.

2. Uncertain diagnosis or suspected "white coat hypertension:" If possible, ambulatory BP monitoring or home BP monitoring may be considered for auxiliary diagnosis. See Table 1 for the diagnostic criteria for hypertension based on ambulatory BP monitoring and home BP monitoring. Refer to Manual for details. Referral is suggested if such resources are not available.

Table 1. Diagnostic criteria for office and out-of-office hypertension

Class	SBP (mmHg)		DBP (mmHg)
Office	≥140	and/or	≥90
Ambulatory blood pressure monitoring			
– Daytime	≥135	and/or	≥85
– Night-time	≥120	and/or	≥70
– 24 hours	≥130	and/or	≥80
Home blood pressure monitoring	≥135	and/or	≥85

3. Conditions necessitating referral (e.g., emergency or critical conditions, secondary hypertension) should be identified (see "Referral" below).

4. Special definitions:

White coat hypertension: a condition where high BP is repeatedly measured in the office setting but ambulatory BP monitoring or home BP monitoring results are normal.

Isolated systolic hypertension: SBP ≥140 mmHg and DBP <90 mmHg.

III. Assessment

The Objective is assessing cardiovascular disease risk, organ impairment, and coexisting clinical conditions. And the assessment is the basis for developing strategies for hypertension treatment. Assessment is recommended at the first visit and on a yearly basis thereafter.

The assessment should include history, physical examination, and auxiliary examination:

History: Past history of diabetes mellitus, stroke, coronary heart disease, heart failure, kidney disease, peripheral atherosclerosis, etc.; familial history of hypertension, diabetes mellitus, dyslipidemia, and early-onset cardiovascular disease; history of smoking and drinking.

Physical examination: BP, heart rate, cardiac rhythm, height, body weight, waist circumference, lower extremity edema, etc.

Auxiliary examination: Routine blood and urine tests, blood chemistries (creatinine, uric acid, alanine transaminase [ALT], potassium, glucose, lipids) and electrocardiogram (ECG; for identification of left ventricular hypertrophy, myocardial infarction, arrhythmias [e.g., atrial fibrillation], etc.). If resources are available: ambulatory BP monitoring, carotid ultrasonography, urine chorionic gonadotropin [UCG], urine albumin/creatinine, chest X-ray, fundus examination, etc.

Treatment of Hypertension

I. Principles of treatment

The three principles of hypertension treatment are adequate control, stabilization, and comprehensive management. The primary objective is to reduce the occurrence of cardiovascular and cerebrovascular diseases and the risk of death.

Adequate control: BP should be adequately controlled. Regardless of the treatment method used, it is essential to control the BP to below target values.

Stabilization: BP should be steadily controlled. Patients should be informed that it is of vital importance to receive lifestyle intervention and drug therapy on a long-term basis and maintain long-term BP stability. Long-acting medications, which are effective at steadily controlling BP and beneficial for reducing cardiovascular complications, are recommended.

Comprehensive management: Comprehensive intervention management of hypertensive patients should be performed. Complications should be considered in the selection of antihypertensive drugs. Additionally, for patients with cardiovascular disease and those with certain risk factors, anti-platelet and lipid-regulating therapies should be administered to reduce the risk of recurrent cardiovascular events and death.

II. Goals of antihypertensive treatment

The treatment goal for general patients with hypertension is: SBP <140 mmHg and DBP <90 mmHg. Patients with concomitant chronic kidney disease or diabetes mellitus are encouraged to a bit lower than this general goal if appropriate. Among patients aged ≥65 years, the treatment goal is: SBP <150 mmHg and DBP <90 mmHg, and if it is tolerable, SBP<140mmHg is encouraged for patients aged 65 to 80 years.

III. Lifestyle intervention

For patients with confirmed hypertension, lifestyle intervention should begin immediately and continue long-term. Patients should follow the six components of a healthy lifestyle: salt restriction, weight loss, exercise, smoking abstinence, alcohol restriction, and peaceful mood. Some lifestyle interventions, such as smoking abstinence, weight loss, and appropriate exercise, can not only significantly lower BP but also prevent cardiovascular disease, and thus should be strongly encouraged. See Table 2 for intervention goals and BP-lowering effects of different lifestyle interventions.

Table 2. Goals and BP-lowering effects of different lifestyle interventions

Intervention	Goal	Obtainable SBP reduction
Salt intake reduction	Daily salt intake ≤6 g (1 beer bottle cap*) per person; caution should be exercised to avoid indirect intake of salt via salted vegetables, chicken essence seasoning, soy sauce, etc.	2-8 mmHg
Weight loss	BMI <24 kg/m^2; waist circumference <90 cm for men or <85 cm for women	5-20 mmHg/ weight loss of 10 kg
Regular exercise	Moderate exercise 5-7 times per week for at least 30 min	4-9 mmHg
Smoking cessation	Abstain from smoking; avoid second-hand smoke	/
Alcohol restriction	Daily alcohol intake: hard liquor <50 mL (50 g), wine <200 mL, beer <500 m	/
Psychological equilibrium	Reduce mental stress; keep a good mood	/

*A common beer bottle cap, with the rubber gasket removed, can accommodate 6 g of salt in the horizontal position.

Discuss lifestyle changes and set goals based on patients' specific health conditions. At each visit, depending on improvement, set a specific short-term target, provide counselling services and encourage patients to keep good habits. To improve compliance, appropriately select 1-2 lifestyles for modification each time depending on patients' willingness. Encourage, supervise and follow patients' performance continually.

IV. Drug therapy

(I) Initiation of therapy

For all hypertensive patients, both drug therapy and lifestyle intervention should begin immediately once the diagnosis of hypertension is confirmed.

For hypertensive patients with SBP <160 mmHg and DBP <100 mmHg and without coronary heart disease, heart failure, stroke, peripheral atherosclerosis, kidney disease or diabetes mellitus, physicians may, depending on the disease condition and the patients' willingness, delay drug therapy and attempt only lifestyle intervention for up to 3 months. If hypertension has not been adequately controlled after this period, drug therapy should be initiated.

(II) Choice of antihypertensive drugs

Treatment from among the five classes of antihypertensive drugs with clear evidence for improving prognosis should be chosen whenever possible. These include ACEIs, ARBs, β receptor blockers, CCBs, and diuretics. These drugs are abbreviated as follows:

A: ACEIs and ARBs. ACEIs and ARBs have clear antihypertensive action and are particularly suitable for use in patients with heart failure, myocardial infarction, diabetes mellitus or chronic kidney disease; sufficient evidence is available indicating they can improve the prognosis. When used in patients with proteinuria, ACEIs/ARBs can lower urine protein; ACEIs/ARBs have kidney-protecting efficacy but are contraindicated in patients with bilateral renal artery stenosis, severe renal insufficiency (creatinine ≥3 mg/dL [265 μmol/L]) or hyperkalaemia. ACEIs/ARBs are contraindicated for pregnant patients and those planning to become pregnant. A known side effect of ACEIs is a dry cough and, if the cough cannot be tolerated, the patient may be switched to ARBs. Both types of drugs may rarely cause angioneurotic oedema.

B: β receptor blockers. β receptor blockers can lower the heart rate and are particularly suitable for use in patients with high heart rates. β receptor blockers can improve prognosis for patients with concomitant myocardial infarction and heart failure, and they can reduce symptoms of angina for patients with coronary heart disease or effort angina. However, caution should be exercised immediately following myocardial infarction and during the acute phase of heart failure (shortness of breath, orthopnea, and inability to lie down); inexperienced primary health care providers should not prescribe the first dose of β receptor blockers for such patients until these disease conditions have stabilized. Alpha- and β receptor blockers that act primarily by blocking β receptors, (e.g., labetalol, carvedilol, arotinolol) are also applicable in the above populations. Because β receptor blockers can lower the heart rate, they are contraindicated in patients with severe bradycardia (e.g., heart rate <55 beats/min, sick sinus syndrome, grade II or III atrioventricular block). β receptor blockers are also contraindicated in patients with asthma. Administration of large doses may affect glycolipid metabolism; however, highly selective β receptor blockers have shown no significant adverse effect on glycolipid metabolism.

C: CCBs. Dihydropyridine CCBs (e.g., amlodipine, nifedipine sustained-release tablets) are the most commonly used antihypertensive medications. With potent antihypertensive efficacy, good tolerability, no absolute contraindications and a relatively broad scope of application, CCBs are often used in elderly patients with isolated systolic hypertension. The most common adverse reactions are headache and ankle edema.

D: Diuretics. Thiazides are commonly used and are particularly suitable for elderly patients, patients with isolated systolic hypertension and patients with concomitant heart failure. The primary side effect of thiazide diuretics is hypokalaemia, with the incidence of hypokalaemia increasing with the dosage. Therefore, a small initial dose is recommended (e.g., hydrochlorothiazide 12·5 mg QD). Diuretics are usually used in combination with ACEIs or ARBs to counteract or reduce the hypokalaemia effects. Thiazide diuretics are often contraindicated in patients with gout. In cases of severe heart failure or chronic renal insufficiency, use of more potent loop diuretics (e.g., furosemide) in combination with potassium supplementation may be necessary; it is suggested that such patients be referred to a higher-level hospital for treatment.

In recent years, fixed-dose combination products of the above classes of drugs have provided new modes of hypertension treatment. These products offer more convenient usage and may assist in long-term compliance; they are therefore recommended.

Other products with clear antihypertensive effects (e.g., compound reserpine tablets and compound hypotensive tablets) may be used depending on patients' conditions.

See the Appendix for usage, indications, contraindications, and adverse reactions of antihypertensive drugs commonly used in primary health care.

(III) Drug therapy regimens

Appropriate drugs, preferentially those that are long-acting, should be chosen based on patients' complications and BP levels. For elderly treatment-naive patients with heart failure in whom postural hypotension is of higher risk, small doses are recommended; for other hypertension patients, each drug may be administered from the commonly used starting dose. See the Appendix for details.

1. Drug therapy regimen for hypertension without complications[1]:

Step I:

SBP <160 mmHg and DBP <100 mmHg: Start therapy with a single drug. A, B, C or D may be selected; B is particularly suitable for patients with high heart rate. Observe for 2-4 weeks with the starting dose; if control remains inadequate, increase the dose, switch to another drug or use two drugs in combination (see below for recommended combinations). Observe for an additional 2-4 weeks after each adjustment.

SBP ≥160 mmHg and/or DBP ≥100 mmHg: Combination of two drugs is recommended (e.g., A+C, A+D, B+C or C+D). Alternatively, use corresponding fixed-dose combination products. In case of inadequate control, increase the doses or change the regimen as described above. Observe for 2-4 weeks after each adjustment.

Step II:

If BP remains inadequately controlled using the two-drug combination, add a third drug. A+B+C or A+C+D may be chosen.

Step III:

If BP remains inadequately controlled using the three-drug combination at sufficient doses for 2-4 weeks, the patient may be directly referred. Alternatively, use four drugs (A, B, C and D) in combination and, if adequate control is not achieved after 2-4 weeks, consider referral.

2. Drug therapy regimens for hypertension with complications[1] (Note: Referral is suggested for acute complications)

Hypertension with myocardial infarction: A+B is preferred and should be administered at low doses. Avoid occurrence of hypotension. In case of inadequate control, the doses may be increased. If adequate control is not achieved after 2-4 weeks, add long-acting C or D (including spironolactone).

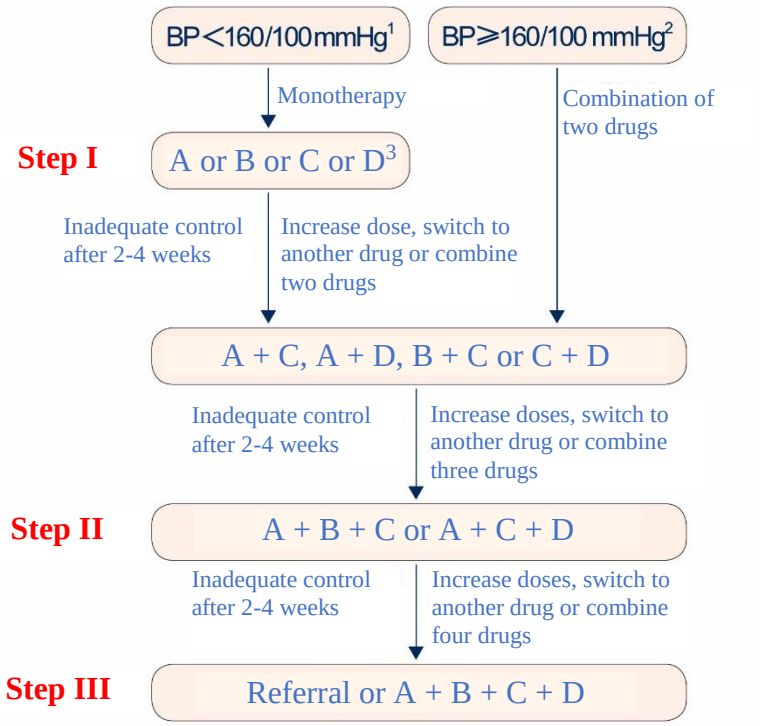
Hypertension with angina: A or B or C may be chosen. These drugs may be used in combination. In case of inadequate control, add D.

Hypertension with heart failure: Use A+B at low doses. In case of concomitant retention of sodium and water, add D. Loop diuretics and supplemental potassium should generally be used in combination. Spironolactone may be additionally administered. In case of control failure, add C (limited to amlodipine and felodipine). In patients with concomitant heart failure, initial treatment with A and B in combination is used to improve prognosis. In patients with low BP, starting doses should be low and then gradually increased.

Hypertension with stroke: A, C or D may be chosen. In case of inadequate control, these drugs may be used in combination.

Hypertension with diabetes mellitus: A is preferred. In case of inadequate control, add C or D.

Flow chart of drug therapy for hypertension without complications



[1]BP<160/100mmHg: SBP <160 mmHg and DBP <100 mmHg.
[2]BP≥160/100mmHg: SBP ≥160 mmHg and/or DBP ≥100 mmHg.
[3]A: angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers; B: β-receptor blockers; C: dihydropyridine calcium channel blockers; D: diuretics (thiazide diuretics are commonly used).
Note: Unless conditions that cannot be tolerated (e.g., adverse reactions) or emergency treatment occur, observe patient for 2-4 weeks after each treatment adjustment to determine whether blood pressure has been adequately controlled.

[1]Complications: concomitant coronary heart disease, heart failure, stroke, diabetes mellitus, chronic kidney disease or peripheral atherosclerosis.

Hypertension with chronic kidney disease: A is preferred. In case of inadequate control, add C or D. If the creatinine level exceeds the normal range for the first time, a higher-level hospital should determine how to proceed with the antihypertensive treatment.

Hypertension with peripheral atherosclerosis: A, B, C or D may be selected during the initial treatment period. If one fails, the drugs may be used in combination, as described under "Drug therapy regimens for hypertension without complications." However, non-selective β-receptor blockers (e.g., propranolol) should be used with caution.

See Table 3 for recommended therapeutic regimens for hypertension with complications.

Table 3. Recommended therapeutic regimens for hypertension with complications[1]

Complication	Step I	Step II	Step III
Myocardial infarction	A+B[2]	A+B+C[3] or A+B+D[4]	Referral or A+B+C[3]+D
Angina	A or B or C	A+B or A+C or B+C	A+B+C or B+C+D
Heart failure	A+B[2]	A+B+D[4]	Referral or A+B+D[4]+C[3]
Stroke	A or C or D	A+C or A+D or C+D	A+C+D
Diabetes mellitus or chronic kidney disease[5]	A	A+C or A+D	A+C+D

A: angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers; B: β-receptor blockers; C: dihydropyridine calcium channel blockers; D: thiazide diuretics.

[1]Complications: concomitant coronary heart disease, heart failure, stroke, diabetes mellitus, chronic kidney disease or peripheral atherosclerosis. Medication regimens for patients with hypertension complicated by peripheral atherosclerosis are the same as those for patients without complications and are therefore not included in this table.

[2]When two drugs are used in combination, treatment should start with the minimum doses so as to avoid hypotension.

[3]Class C drugs indicated for myocardial infarction are limited to long-acting drugs. Class C drugs indicated for heart failure are limited to amlodipine and felodipine.

[4]Class D drugs include spironolactone when indicated for myocardial infarction and include loop diuretics and spironolactone when indicated for heart failure.

[5]If the creatinine level exceeds the normal range for the first time after treatment initiation, the antihypertensive treatment regimen should be at the discretion of a superior hospital.

(IV) Precautions for drug use

After each medication change or dose adjustment, patients should be observed for 2–4 weeks to evaluate drug effectiveness. Frequent switching of drugs should be avoided unless conditions occur that cannot be tolerated (e.g., adverse reactions) or emergency treatment is required.

ACEIs and ARBs are usually not used in combination.

A+B is not recommended as a routine combination, with the exception of patients with myocardial infarction and heart failure.

(V) Recommendations for therapeutic regimen adjustment in patients who have previously received drug treatment

Adequate control: For patients without complications, the prior therapeutic regimen may be maintained if BP remains adequately controlled. For patients with the previously mentioned complications, the therapeutic regimens in Table 3 are recommended.

Inadequate control: Medication adjustment is recommended in accordance with the therapeutic regimens in Tables 3 and 4.

If BP control cannot be realized for objective reasons, adequate control of BP should be set as the fundamental goal of treatment and use of other types of antihypertensive drugs is allowed.

For occasional BP fluctuations in patients whose BP has been adequately controlled with medications, potential causes of the fluctuations should be excluded to avoid frequent adjustment of drugs based on individual BP measurements.

(VI) Comprehensive intervention management

Complications should be comprehensively considered in the selection of antihypertensive drugs, as described above. Additionally, for patients who have developed cardiovascular disease and those with certain risk factors, aspirin and

statins should be considered to reduce the risk of recurrent cardiovascular events and death. Recommendations are detailed below:

1. Low-dose aspirin: Aspirin 75-100 mg QD is recommended in hypertensive patients with coronary heart disease, ischemic stroke or peripheral atherosclerosis if BP has been steadily controlled below 150/90 mmHg. Aspirin is contraindicated in patients with active gastric ulcer or gastrointestinal haemorrhage or hypersensitivity.

2. Lipid regulators including statins: For patients with coronary heart disease, ischemic stroke, and peripheral atherosclerosis, statins should be administered on a long-term basis and, when necessary, other medications should be added to lower low-density lipoprotein cholesterol (LDL-C) to below 1·8 mmol/L (70 mg/dL). Lipid-lowering medications (including statins) should also be used in patients with the following diseases or conditions: (1) chronic kidney disease; (2) diabetes mellitus; (3) severe hypercholesterolemia: total cholesterol (TC) ≥7·2 mmol/L (278 mg/dL) or LDL-C ≥4·9 mmol/L (190mg/dL); (4) at least two of the following three risk factors: smoking, high-density lipoprotein cholesterol (HDL) <1 mmol/L (40 mg/dL), or age ≥45 years for men/≥55 years for women. For patients with hypertension complicated by chronic kidney disease, it is suggested that LDL-C be lowered to <1·8 mmol/L (70 mg/dL); for patients with other conditions, it is suggested LDL-C be lowered to <2·6 mmol/L (100 mg/dL). For hypertensive patients without the specified concomitant conditions but with LDL-C ≥3·4 mmol/L (130 mg/dl), statins are recommended to lower LDL-C to <3·4 mmol/L (130 mg/dL; see Table 4 for details).

Table 4. Lipid-regulating goals for patients with hypertension complicated by related disorders or conditions

Diseases/conditions complicating hypertension	Target value of LDL-C
Coronary heart disease Ischemic stroke Peripheral atherosclerosis Chronic kidney disease Diabetes mellitus TC ≥7·2 mmol/L (278 mg/dL) or LDL-C ≥4·9 mmol/L (190 mg/dL)	<1·8 mmol/L (70 mg/dL)
Smoking + HDL <1 mmol/L (40 mg/dL) Smoking + age ≥45 years for men/≥55 years for women HDL-C <1 mmol/L (40 mg/dL) + age ≥45 years (men)/≥55 years (women)	<2·6 mmol/L (100mg/dL)
LDL-C ≥3·4 mmol/L (130mg/dL; if none of the above conditions)	<3·4 mmol/L (130 mg/dL)

Abbreviations: LDL-C, low-density lipoprotein cholesterol; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol.

Examples of common statin dosages include the following: simvastatin 20-40 mg QN; atorvastatin 10-20 mg QD; and rosuvastatin 5-10 mg QD. If LDL-C is not adequately lowered with treatment, the doses may be appropriately increased or other cholesterol-lowering agents may be additionally administered (e.g., cholesterol absorption inhibitors). Observe for 3-6 months. Referral is suggested if LDL-C remains uncontrolled.

Statins are well tolerated overall. Side effects may include myopathies, rhabdomyolysis, and elevated transaminases, with the risk increasing with dose. For treatment-naive patients, blood lipid, transaminases, and creatinine kinase should be re-examined within 6 weeks. In the absence of adverse reactions and adequate lowering of LDL-C, the follow-up frequency may be reduced to once every 6-12 months. See the Manual for specific dosage, lipid-lowering potency and precautions for statins.

(VII) Emergency treatment of BP ≥180/110 mmHg

1. BP ≥180/110 mmHg without clinical symptoms of acute heart, brain, or kidney complications:[2]

(1) Oral short-acting antihypertensive drugs (e.g., captopril 12·5-25 mg, nifedipine 10 mg or metoprolol 25 mg, per os), which may be repeated after 1 hour; the patient should visit the outpatient department until BP is <180/110 mmHg

(2) Referral is suggested if BP remains ≥180/110 mmHg or symptoms are overt

(3) Lower BP to <160/100mmHg within 24-48h, and thereafter adjust the long-term therapeutic regimen

[2]Acute heart, brain and kidney complications include hypertensive cerebropathy, cerebral hemorrhage, subarachnoid hemorrhage, cerebral infarction, dissecting aneurysm of aorta, acute heart failure, pulmonary edema, unstable angina, acute myocardial infarction, etc.

(4) Warning: Sublingual use of short-acting drugs, including nifedipine, for rapidly lowering BP is strongly discouraged!

2. BP ≥180/110 mmHg with clinical symptoms of acute heart, brain, or kidney complications:[3]

(1) Immediate referral

(2) Administer simple treatment by reference to the Manual while waiting for referral

Referral

Populations in need of referral include patients with acute onset, severe symptoms, suspected secondary hypertension, or refractory hypertension that cannot be controlled using multiple drugs. Treatment in primary health care institutions is also not recommended for pregnant or lactating female hypertensive patients. Medical workers in primary health care institutions should follow up within 2 weeks after referral to a higher-level hospital for diagnosis and assessment of treatment effectiveness. Once adequate BP control has been achieved, routine primary care follow-up should resume. If the hypertension diagnosis is not confirmed or BP remains uncontrolled, the patient should remain under the care of the higher-level hospital for further treatment.

Indications for referral during first visit:

(1) Marked BP increase to ≥180/110 mmHg and failure to control with short-term treatment
(2) Suspected new onset of heart, brain or kidney complications or other severe clinical conditions
(3) Pregnancy or lactation
(4) Onset age <30 years
(5) Concomitant proteinuria or haematuria
(6) Hypokalaemia not associated with diuretics
(7) Paroxysmal BP increase complicated by headache, palpitation, and diaphoresis
(8) Upper extremity SBP difference >20 mmHg
(9) Further examination in the hospital needed for diagnosis

Indications for referral at follow-up visit:

(1) Inadequate BP control with at least three types of antihypertensive drugs administered at sufficient doses
(2) Significant BP fluctuations that are difficult to control
(3) Suspected adverse reaction to antihypertensive drug that is difficult to tolerate
(4) Severe clinical condition or heart, brain, or kidney impairment found during follow-up that is difficult to manage

Indications for urgent referral by ambulance:

(1) Loss of consciousness or confusion

(2) BP ≥180/110 mmHg complicated by severe headache, vomiting or sudden dysphonia and/or limb paralysis

(3) Significant BP increase with persistent intense chest-back pain

(4) BP increase complicated by lower extremity edema, dyspnoea or inability to lie down

(5) Chest distress or chest pain persisting ≥10 minutes, with diaphoresis and ST-segment elevation in at least two leads in ECG (Figure); referral should occur as soon as possible, and thrombolysis or emergency coronary interventional therapy should be considered

(6) Other serious condition affecting vital signs (e.g., faint awareness complicated by hypotension or unmeasurable BP, excessively low or high heart rate, sudden serious systemic anaphylaxis)

~~Long-term Management of Hypertension~~

~~Follow-up frequency~~

~~Follow-up once every 3 months. If BP did not achieve the goal, arrange additional follow-up visit within 2 weeks, and referral if still failed to achieve the goal.~~

~~What to do during the follow-up visit~~

~~Follow-up should include assessment of newly diagnosed concomitant diseases including coronary heart diseases, heart failure, stroke, diabetes mellitus, chronic kidney diseases, peripheral arterial diseases, physical examination (BP, heart rate, etc.; body weight and waist circumference in every 3 months for overweight or obesity patients), lifestyle assessment and suggestions, drug compliance and tolerance assessment, and treatment adjustment (if necessary).~~

~~Annual assessment~~

~~In addition to the 3-month follow-up assessment, body weight and waist circumference should be re-measured and necessary auxiliary examinations should be conducted, including routine blood and urine tests, biochemistry (creatinine, uric acid, ALT, blood potassium, blood glucose, blood lipid), and ECG. When appropriate, the following tests should also be considered: ambulatory BP monitoring, UCG, carotid ultrasonography, urine albumin/creatinine, chest X-ray, fundus examination, etc.~~

Usage, indications, contraindications and adverse reactions of common antihypertensive drugs[1]

	Name	Single Dose	Administration (times/day)	Recommended Usual Starting Dosage[2]	Indications[3]	Contraindications[3]	
	Enalapril	5-20 mg	1-2	5 mg Bid	Heart failure, post-myocardial infarction, left ventricular hypertrophy, peripheral atherosclerosis, diabetic nephropathy, non-diabetic nephropathy, proteinuria, microproteinuria, metabolic syndrome, diabetes mellitus	Absolute contraindications: pregnancy, hyperpotassemia, bilateral renal artery stenosis; Relative contraindications: severe renal insufficiency (creatinine >3 mg/dL [265 μmol/L]), possible pregnancy	
	Captopril	12·5-50 mg	2-3	12·5 mg Tid			
	Perindopril	4-8 mg	1	4 mg Qd			
	Benazepril	10-20 mg	1-2	10 mg Qd			
	Ramipril	1·25-10 mg	1	5 mg Qd			
	Fosinopril	10-40 mg	1	10 mg Qd			
	Lisinopril	5-80 mg	1	10 mg Qd			
	Imidapril	2·5-10 mg	1	5 mg Qd			
	Valsartan	80-160 mg	1	80 mg Qd	Heart failure, post-myocardial infarction, left ventricular hypertrophy, diabetic nephropathy, proteinuria, microalbuminuria, metabolic syndrome, diabetes mellitus, ACEI-associated cough	Same as ACEI	
	Losartan	25-100 mg	1	50 mg Qd			
	Irbesartan	150-300 mg	1	150 mg Qd			
	Telmisartain	20-80 mg	1	40 mg Qd			
	Candesartan	4-12 mg	1	4 mg Qd			
	Olmesartan medoxomil	20-40 mg	1	20 mg Qd			
	Atenolol	6·25-25 mg	1-2	6·25 mg Bid	Angina, post-myocardial infarction, tachyarrhythmia, heart failure, pregnancy-induced hypertension (labetalol)	Absolute contraindications: grade II or III atrioventricular block, asthma; Relative contraindications: chronic obstructive pulmonary disease, peripheral arteriopathies	
	Metoprolol	12·5-100 mg	2	25 mg Bid			
	Metoprolol Sustained-release Tablets	23·75-190 mg	1	47·5 mg Qd			
	Bisoprolol	2·5-10·0 mg	1-2	5 mg Qd			
	Carvedilol	3·125-25 mg	2	6·25 mg Bid			
	Arotinolol	5-10 mg	2	5 mg Bid			
	Labetalol	100-200 mg	2	100 mg Bid			

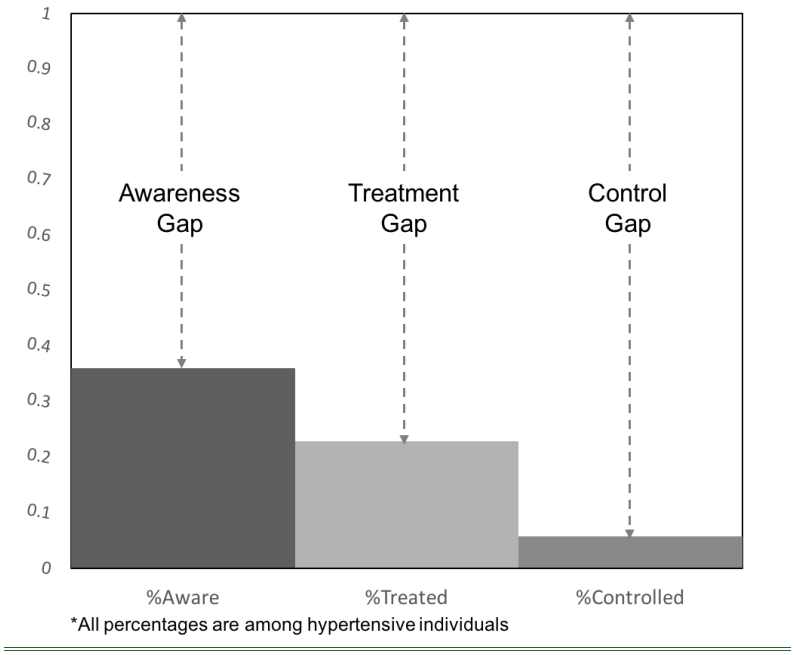
Name	Single Dose	Administration (times/day)	Recommended Usual Starting Dosage[2]	Indications[3]	Contraindications[3]
Amlodipine	2·5-10 mg	1	5 mg Qd	Left ventricular hypertrophy, senile isolated systolic hypertension, angina, atherosclerosis, metabolic syndrome	Relative contraindications: rapid arrhythmia, congestive heart failure
Levamlodipine	2·5-5 mg	1	2·5 mg Qd		
Nifedipine	10-20 mg	2-3	5 mg Tid		
Nifedipine sustained-release tablets	10-20 mg	1-2	20 mg Bid		
Nifedipine controlled-release tablets	30-60 mg	1	30 mg Qd		
Nitrendipine	10-20 mg	2	10 mg Bid		
Felodipine sustained-release tablets	2·5-10 mg	1	5 mg Qd		
Lacidipine	2-8 mg	1	2mg Qd		
Benidipine	2-8 mg	1	2 mg Qd		
Lercanidipine	10-20mg	1	10 mg Qd		
Cilnidipine	5-10 mg	1	5 mg Qd		
Hydrochlorothiazide	6·25-25 mg	1	12·5 mg Qd	Senile isolated systolic hypertension, heart failure	Absolute contraindications: gout; Relative contraindications: pregnancy
Indapamide	1·25-2·5 mg	1	1·25 mg Qd		
Amlodipine benazepril	1 tablet	1	1 tablet Qd	Hypertension not adequately controlled with a single drug or requiring more than two drugs for treatment	Contraindications of corresponding components
Benazepril hydrochlorothiazide	1 tablet	1	1 tablet Qd		
Compound captopril	1-2 tablets	2-3	1 tablet Tid		
Lisinopril hydrochlorothiazide	1 tablet	1	1 tablet Qd		
Enalapril hydrochlorothiazide (II)	1 tablet	1	1 tablet Qd		
Irbesartan hydrochlorothiazide	1 tablet	1	1 tablet Qd		
Losartan hydrochlorothiazide	1 tablet	1	1 tablet Qd		
Telmisartain hydrochlorothiazide	1 tablet	1	1 tablet Qd		
Valsartan hydrochlorothiazide	1-2 tablets	1	1 tablet Qd		
Valsartan amlodipine	1 tablet	1	1 tablet Qd		
Compound reserpine tablets	1-3 tablets	2-3	1 tablet Tid	Hypertension not adequately controlled with a single drug or requiring more than two drugs for treatment	Contraindications for corresponding components
Compound reserpine triamterene tablets	1 tablet	1	1 tablet Qd		Active ulcer

G. Lifetime health and cost consequences prediction based on a state-transition simulation model

We used a state-transition simulation model to predict the lifetime health and cost consequences of cardiovascular disease (CVD) and hypertension in the 1.7 million individuals in the China Patient-centred Evaluative Assessment of Cardiac Events (China PEACE). Specific outcomes include life expectancy, Quality-adjusted Life Years

(QALYs), antihypertensive drug cost, CVD event cost, chronic CVD management cost, and productivity. The projected health and economic effects are rescaled and age- and gender- standardized to represent the entire Chinese population aged 35 to 75 years.

In the model, we simulated four scenarios for different proportions of hypertension awareness, treatment and control: 1) Current, 2) All-aware, 3) All-treated, and 4) All-controlled. The “all-aware” scenario assumes that all hypertensive individuals are diagnosed but the diagnosed individuals are only proportionally treated and controlled; the “all-treated” scenario assumes that all hypertensive individuals are treated but the treated individuals are only proportionally controlled (based on the treatment and control proportions in the current scenario); and the “all-controlled” scenario assumes that all hypertensive individuals are controlled. Therefore, the “awareness gap” is defined as the gap between the all-aware scenario and the current scenario; the “treatment gap” is defined as the gap between the all-treated scenario and the current scenario; and the “control gap” is defined as the gap between the all-controlled scenario and the current scenario (see the figure below).



1These drugs are included in the National Essential Drug List (2017) and National List of Drugs for Basic Medical Insurance, Work-Related Injury Insurance and Maternity Insurance (2017).

2The recommended usual starting dosage is applicable for general hypertensive patients. For patients with concomitant heart failure or geriatric patients aged ≥80 years with high risk of postural hypotension, initial treatment with a smaller dose is recommended. Qd indicates once daily; Bid, twice daily; Tid, three times daily.

3The pa

H. Primary health care professionals in China

Primary health care requires multidisciplinary professional teams that consist of doctors, nurses, pharmacists, and other health workers. Different types of primary health care professionals, and the synergy between them, are crucial for the system to provide comprehensive and high-quality services. In 2018, the primary health care workforce consisted of approximately 1 310 000 physicians, 907 000 village doctors, 852 000 nurses, 147 000 pharmacists, and 106 000 technicians.[4,36] As the backbone of the workforce, primary health care physicians and village doctors in China have a unique portfolio in comparison with other countries. There were 471 000 licensed physicians or licensed assistant physicians in urban areas, and 834 000 licensed physicians or licensed assistant physicians in addition to 907 000 village doctors in rural areas.[4,36] It takes 5 years of medical education after 12 years of primary and secondary education to become a licensed physician or 3 years of medical education after 12 years of primary and secondary education to become a licensed assistant physician, and regular and assistant physicians must pass the national practicing doctor (or assistant doctor) examination and periodic government assessments to maintain their licenses.

It is worth noting that most physicians in China have not been trained to be, or qualify as, general practitioner as it is defined in many other countries, since the development of China's general practitioner training system began in 2011. Village doctors need only a technical school education (3 years of medical education after 9 years of primary and secondary education) or 20 years of continuous practicing experience to work in village clinics. Village doctors practice with a village doctor certificate, rather than a regular license, and cannot practice in other types of health care institutions.

~~F.~~I. Relevant key features of the State Council guidance on reform and development of training and incentive mechanisms for general practitioners

Goals: To establish a comprehensive primary health care physician training system, to have five qualified primary health care physicians available for every 10 000 residents in China by 2030.

Establish and strengthen a comprehensive primary health care physician training system

- Deepening undergraduate medical education reform
  - Medical schools should attach high importance to the development of general practice. All medical students should receive training in the principles and practice of general practice. Medical schools should be encouraged to develop a unit dedicated to general practice.
  - Qualified primary health care physicians with teaching potentials should be encouraged to become teaching faculty.
  - Continue the implementation of tuition sponsorship for medical students who commit to primary health care physician residency training after graduation in rural areas.
- Develop a postgraduate primary health care physician training system
  - General practice should be given preferential consideration with newly created standardised residency training positions, with the aim of 20% of total positions dedicated to general practice by 2020.
  - General hospitals that have been certified as bases for standardized residency training should intensify general practice training. They should establish clinical units of general practice and jointly train primary health care physicians with primary health care institutions.
  - Training standards for primary health care physician trainers should be formulated. Promotion of the trainers will be dependent upon the quality of their teaching. Hospitals that are standardized residency training bases are encouraged to collaborate closely with medical schools.
- Strengthen continuous medicine education (CME) in general practice
  - Develop training guidelines on CME for primary health care physicians
  - Intensify the development of web-based programs. Enhance the role of county-level hospitals in providing CME for primary health care physicians in rural areas.
  - Strengthen training on traditional Chinese medicine and rehabilitation in CME.
  - Encourage hospital doctors from other specialties to be re-trained to become primary health care physicians.

Improve career attractiveness of primary health care physicians

- Reform the remuneration system for primary health care physicians
  - Raise the salary level of primary health care physicians at primary health care institutions to levels equivalent to physicians within local county-level hospitals. Establish a mechanism of salary growth linked to a pay-for-performance model.
  - Encourage primary health care institutions to recruit primary health care physicians who have completed standardized residency training.
  - Include fee for “family doctor service” as an income component of primary health care institutions. Use patients’ satisfaction rates and health outcomes as indicators of performance and link this with income.
- Improve the employment and management of primary health care physicians
  - County-level hospitals can recruit and allocate primary health care physicians who have undergone standardised residency training to their subordinate township health centres. Similarly, township health

centres can recruit assistant primary health care physicians who have undergone training and allocate them to village clinics.

- Introduce special measures for primary health care physicians who have completed the standardized residency training to enhance their prospects for promotion.
- Encourage non-governmental organizations to set up primary health care physician clinics. A two-way referral system should be encouraged between general hospitals and these primary health care physician GP clinics. Primary health care physician clinics operating on a non-profit basis should be allowed to enjoy similar benefits and support as government-run primary health care institutions.
- Elevate the social status of primary health care physicians with local and national awards.

Strengthen the development of primary health care physician capacity in deprived areas

- Prioritize the allocation of assistant primary health care physicians who graduate from tuition sponsoring schemes to village clinics and township health centres in deprived and remote areas. Develop free online CME for primary health care physicians working in remote areas.
- Expand the scope of "special primary health care physician posts programs" (posts created in addition to those in established budgets) for deprived rural areas by increasing the financial subsidy for such programs from central and local government treasuries.
- Introduce special measures to enhance prospects for promotion for those who have practiced in deprived areas for more than ten years after completing standardised residency training.

Safeguarding the implementation of policies

- Strengthen organizational arrangements to ensure implementation of the above measures
- Explore new mechanisms whereby financial rewards are provided to primary health care professionals through using capitation fees from "family doctor service", and a fee to be paid by family doctor teams to the hospital if a patient is referred.
- Ensure that all levels of government and other sources provide adequate funding for these measures, which will be closely monitored.
- Include primary health care physician training and implementation of this guidance as a part of the assessment of progress in health care reform, with regular investigations and supervision.
- Create a positive image of primary health care physicians and their roles through various forms of publicity.

Author Response Letter

THELANCET-D-19-05919, Quality of Primary Health Care in China: Challenges and Recommendations

We thank the reviewers for their thoughtful comments, which have helped us to improve the manuscript substantially. We have complied with the Editor's specific requests and have responded to each comment (reproduced in **bold**) and detailed our changes to the manuscript (quoted in *italic*). The page and line numbers that we reference below are based on the clean version of our revised manuscript. Before we address the comments in more detail, however, we wish to provide an overview of the changes included in this revision.

The major issues raised by the reviewers and the main responses generally fell within three areas:

1) Literature search conducted 3 years ago.

We updated the literature search on Dec 30th during this revision to include more recent evidence, which are mainly about the quality gaps in the section "*Current Quality of China's Primary Health Care*" and system causes in the section "*Challenges in Structure and Process of Primary Health Care System*".

2) The method to generate recommendations.

The analytical approach that we used for this Review is one that is commonly used in policy research, which follows the following process: 1) problem identification; 2) analysis of underlying causes; 3) policy recommendation for addressing the causes; 4) experimentation of the recommendation. In this Review, we summarize the problems that already exist, use the European Primary Care Monitoring System framework to guide us in identifying relevant causes, which led to recommendations. We briefly explained our analytical approach in the third paragraph of section "*Introduction*".

3) The recommendation about information system and learning health system.

We agree that training, incentives, and coordination are more important strategies to address quality issues, so we moved the recommendation about learning health system to the end of the section "*Recommendations for Improvement*". This recommendation, as a vision of future PHC system, was shortened.

In the following pages, we elaborate further on the modifications and others in our detailed responses to the Editor's requests and reviewers' specific comments.

EDITOR COMMENTS

Please note, we have sent out the views of the two papers together and we would hope to combine the two papers into one.

Response: As suggested, in this resubmission we have combined the two reviews into one that focuses on quality of primary health care in China.

Please note that not every point below will be relevant to your manuscript.

1. Please indicate after each of the reviewers' points the text changes which have been made (if any) and the line number on the revised manuscript at which your change can be found. [Line numbers can be added to your word document using the 'page layout' tab. Please select continuous numbers.]

Response: We have made a track change version and a clean version of the manuscript after this revision. We also added line number into the clean version of our revised manuscript, and for each change, we have indicated the page number and line number in this response letter.

2. When interpreting editorial points made by reviewers, please remember we will edit the final manuscript if accepted.

Response: We have considered each of the comments carefully and have done our best to respond appropriately. In some cases, the comment asked for the addition of content that was beyond the scope of this manuscript. To address that, we have sought to clarify the boundaries of this paper and have politely declined to expand the paper. We defer to the wishes of the Editors in these situations.

3. Please indicate any authors who are full professors.

Response: We have indicated that information in the cover page.

4. Please list the highest degree for each author (one degree only, please).

Response: We have indicated that information in the cover page.

5. Please check that all author name spellings and affiliations are correct.

Response: All authors have confirmed name spellings and affiliations.

6. For randomised trials please follow the CONSORT reporting guidelines (http://www.consort-statement.org) and CONSORT for abstracts

(http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(07)61835-2/fulltext), and include a CONSORT checklist with your resubmission.

Response: This comment is not applicable for our manuscript.

7. Please ensure that the title of the paper is non-declamatory (ie, it describes the aim of study rather than the findings) and that it includes a description of the study type (eg, a randomised controlled trial).

Response: This comment is not applicable for our manuscript.

8. Please limit the summary to pre-defined primary endpoints and safety endpoints.

Response: This comment is not applicable for our manuscript.

9. For RCTs, please state the trial registration number.

Response: This comment is not applicable for our manuscript.

10. At the end of the methods section please state the role of the funder in: data collection, analysis, interpretation, writing of the manuscript and the decision to submit. Please also state which author(s) had access to all the data, and which author(s) were responsible for the decision to submit the manuscript etc.

Response: This comment is not applicable for our manuscript.

11. Please explain any deviations from the protocol.

Response: This comment is not applicable for our manuscript.

12. Please report all outcomes specified in the protocol.

Response: This comment is not applicable for our manuscript.

13. If any exploratory outcomes are reported that were not pre-specified, please make it clear that these analyses were post-hoc.

Response: This comment is not applicable for our manuscript.

14. Please use rINNs for drug names. For genes and proteins, authors can use their preferred terminology so long as it is in current use by the community, but should provide the preferred human name from Uniprot

(http://www.uniprot.org/uniprot/) for proteins and HUGO (http://www.genenames.org) for genes at first use to assist non-specialists.

Response: This comment is not applicable for our manuscript.

15. For drug studies, please ensure that details of doses, route of delivery, and schedule are included.

Response: This comment is not applicable for our manuscript.

16. For the main outcome measures, please include a result for each group, plus a point estimate (eg, RR, HR) with a measure of precision (eg, 95% CI) for the absolute difference between groups, in both the Summary and the main Results section of the paper.

Response: This comment is not applicable for our manuscript.

17. p-values should be exact, but no longer than 4 decimal places (eg p<0.0001). Two decimals are acceptable in tables for non-significant p-values

Response: This comment is not applicable for our manuscript.

18. Please provide absolute numbers to accompany all percentages. Percentages should be rounded to whole numbers unless the study population is very large (>10 000 individuals).

Response: This comment is not applicable for our manuscript.

19. Please give 95% confidence intervals for hazard ratios/odds ratios.

Response: This comment is not applicable for our manuscript.

20. For means, please provide standard deviation (or error, as appropriate).

Response: This comment is not applicable for our manuscript.

21. Please provide interquartile ranges for medians.

Response: This comment is not applicable for our manuscript.

22. Please provide numbers at risk for Kaplan-Meier plots and ensure that plots include a measure of effect (eg, log-rank p); estimates should be reported with 95% CIs.

Response: This comment is not applicable for our manuscript.

23. Please ensure that the Discussion contains a section on limitations of the study.

Response: This comment is not applicable for our manuscript.

24. Please provide the text, tables, and figures in an editable format. See link above this list for details of acceptable formats for figure files.

Response: We have included the editable files of each figure (MS PowerPoint file) and table (MS Word file) in the resubmission.

25. Our production system is not compatible with Endnotes. Please convert to normal text.

Response: In our submitted MS Word files, all citations and bibliography had been converted to normal text.

26. If accepted, only 5-6 non-text items (figures, tables, or panels) can be accommodated in the print edition; additional material can be provided in a web appendix. Please indicate which items can go in a web appendix.

Response: Our manuscript includes 6 panels in addition to the 'Key Messages'. Items in appendix were indicated in the main text of our manuscript.

27. Please provide a research in context panel with 3 parts: Evidence before this study (which includes a description of how you searched for evidence and how you assessed the quality of that evidence); Added value of the study; and Implications of all the available evidence.

Response: This comment is not applicable for our manuscript.

28. At the end of the manuscript, please summarise the contribution of each author to the work.

Response: We have included a section *Author Contributions* at the end of our manuscript (Page 22, Line 453-458).

29. At the end of the manuscript please summarise the declaration of interests for each author.

Response: We have included a section *Declaration of Interests*, indicating the authors declared no relevant conflict of interest, at the end of our manuscript (Page 22, Line 460-461).

30. If you have not yet done so, please return all signed authorship statements and conflict of interest forms. We also require signed statements from any named person in the acknowledgements saying that they agree to be acknowledged.

Response: We have included signed authorship statements and conflict of interest forms for each author in the resubmission. Each person named in the acknowledgements provided an email as enclosed in submission that he/she agree to be acknowledged.

31. For any personal communication, please provide a letter showing that the person agrees to their name being used.

Response: This comment is not applicable for our manuscript, as no personal communication was included.

32. As corresponding author, please confirm that all authors have seen and approved of the final text.

Response: All authors have approved the submission and provided signed authorship statements.

33. If your author line includes a study group, collaborators' names and affiliations may be listed at the end of the paper or in the appendix. Additionally, if you wish the names of collaborators within a study group to appear on PubMed, please upload with your revision a list of names of all study group members presented as a two-column table in Word. First and middle names or initials should be placed in the first column, and surnames in the second column. Names should be ordered as you wish them to appear on PubMed. The table will not be included in the paper itself - it's simply used to make sure that PubMed adds the names correctly.

Response: This comment is not applicable for our manuscript, as no study group was included.

34. Please note our guideline length for research articles is 3500 words and 30 references. For RCTs, the text can be expanded to 4500 words.

Response: We noted that the guideline length for reviews is 5000 words. The length of our revised manuscript is 4978 words (not including panels, tables, figure legends, or references).

35. From July 1, 2018, all submitted reports of clinical trials must contain a data sharing statement, to be included at the end of the manuscript or in an appendix (please provide as a separate pdf). Data sharing statements must indicate:
***Whether data collected for the study, including individual participant data and a data dictionary defining each field in the set, will be made available to others;**
***What data will be made available (deidentified participant data, participant data with identifiers, data dictionary, or other specified data set);**
***Whether additional, related documents will be available (eg, study protocol, statistical analysis plan, informed consent form);**
***When these data will be available (beginning and end date, or "with publication", as applicable);**
***Where the data will be made available (including complete URLs or email addresses if relevant);**
***By what access criteria data will be shared (including with whom, for what types of analyses, by what mechanism - eg, with or without investigator support, after approval of a proposal, with a signed data access agreement - or any additional restrictions).**

Clinical trials that begin enrolling participants on or after Jan 1, 2019, must include a data sharing plan in the trial's registration. If the data sharing plan changes after registration, this should be reflected in the statement submitted and published, and updated in the registry record. For reports of research other than clinical trials, data sharing statements are encouraged but not required. Mendeley Data (https://data.mendeley.com) is a secure online repository for research data, permitting archiving of any file type and assigning a permanent and unique digital object identifier (DOI) so that the files can be easily referenced. If authors wish to share their supporting data, and have not already made alternative arrangements, a Mendeley DOI can be referred to in the data sharing statement.

Response: This comment is not applicable for our manuscript.

REVIEWERS COMMENTS

Reviewer #1:

1. **It's not possible to referee this paper without referencing an accompanying paper on "Access to Primary Health Care in China". The first paper provided an extensively referenced review of a range of aspects of care in China, going some way beyond access to workforce issues and, in the opinion I gave, adding little to a previous paper from the same authors published in The Lancet in 2017. Although extensively referenced, I also had some doubts about the care with which some individual references had been cited in paper 1. This paper is a complete contrast. I was slightly surprised at the title as access (the subject of the first paper) is a key component of access in most frameworks of quality including that quoted by these authors in panel 2 of this paper. So I wondered why there was a need for two papers.**

Response: As the Editor and reviewers suggested, we combined the two reviews – on access and quality separately – into one, which is now mainly about quality of primary health care in China.

2. **Anyhow, having recently published a paper on the quality of primary care in China myself, I looked forward to reading the paper. There is no comment on the methods used in the paper, though the supplementary material includes a paragraph outlining the search process which included papers up to 2016 (I think the review of paper 1 went up to 2017), so they are clearly relying on an old review here).**

Response: We appreciate this comment. We updated the literature search on Dec 30th in this revision (see appendix and the table below), and included more recent evidence, mainly in the section '*Current Quality of China's Primary Health Care*' and '*Challenges in Structure and Process of Primary Health Care System*'.

Search Topic	**Papers in English (PubMed)** Searched / Relevant	**Papers in Chinese (CNKI)** Searched / Relevant
EHR System	32 / 7	63 / 2
Medications	100 / 11	80 / 8
Quality	2619 / 28	610 / 10
Human resources	1483 / 20	32 / 5
Insurance	225 / 16	15 / 0
Financial	430 / 4	46 / 5
Structural	841 / 7	278 / 14

3. **Then the results. This section, 'Current Quality of China's Primary Health Care', takes up just over one A4 side of a manuscript that is 41 pages long. The section on quality of diagnosis and treatment has just one reference (and that**

is a study using simulated case histories) and the section on chronic disease management considers just one condition, hypertension.

Response: The reviewer is correct that the section '*Current Quality of China's Primary Health Care*' was relatively short. We intended to limit the length of this section because the major aim of this manuscript is to identify causes for poor quality of care and provide recommendations for improvement. In this revision, we clarified that in the section '*Introduction*' (Page 7, Line 58-59).

> *In this review, we summarize the evidence on quality of PHC in China, analyse the causes for poor quality of care and provide policy recommendations for improvement.*

In this revision, we added new high-quality evidence on more conditions after the updated literature search. For quality of diagnosis, we included a multi-center study using incognito standardized patient with classic pulmonary tuberculosis symptoms, which can provide international comparison findings (Page 8, Line 91-95).

> *In another study using incognito standardized patient with classic pulmonary tuberculosis symptoms, correct management proportions at township health centres (38%) and village clinics (28%) were significantly lower than at county hospitals (90%).[1] There is a significant variation of observed doctors' behaviour within each group (township health centres or village clinics) as well,[1] which was similar in other middle-income countries.[2]*

For prescribing behaviour, we indicated the proportion of inpatient antibiotics prescriptions that were deemed inappropriate, and the preference of PHC physicians to use broad-spectrum (Page 9, Line 99-105).

> *A 2011 study based on a random sample of PHC institutions in 6 provinces of China also revealed that a quarter of outpatient antibiotics prescriptions and 68% of inpatient antibiotics prescriptions were inappropriate, and improper remuneration incentives was considered a key driver for these prescribing behavior.[3] Moreover, there was a preference of PHC doctors to use broad-spectrum antibiotics,[4] which is deemed quality issue related to professional incompetence,[5] and could induce the emergence and spread of drug-resistant strains of microbes.[5]*

For chronic disease management, in addition to hypertension, we included two studies on diabetes, since both hypertension and type 2 diabetes are the most common chronic conditions encountered in China's primary health care settings, and primary care providers are tasked with identifying and managing these two conditions as part of the national basic public health services package (Page 10, Line 126-133).

For diabetes, a nationally representative survey in 2013 of 170,287 Chinese participants found that only 37% of those with diabetes were aware of their diagnosis, and just 32% were being treated.[6] Another nationwide longitudinal survey from 2011 to 2015 identified a decrease in health education coverage (from 76% to 70%) and persisted gaps in use of examinations and treatments (from 79% to 81%), accompanied by an increase in both diabetes-related hospital admission (from 4% to 6%) and readmission (from 19 to 28%).[7] China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).[8]

Additionally, we noted the evidence about other measures for quality of care in the European Primary Care Monitoring System (Page 8, Line 76-81).

With respect to other measures covered by the EPCMS, China has already achieved maternal and child health outcomes that approach those of advanced economies,[9] and universal neonatal vaccination was estimated to have prevented 30 million chronic Hepatitis B viral carriers.[10] Unfortunately evidence on quality of mental health care and health promotion in PHC system is not generally available.

4. **The rest of the paper is largely taken up with a discussion of workforce challenges, remuneration systems, coordination and continuity of care (four and a half sides for these, partially repeating points made in paper 1) and recommendations for improvement (six and a half sides). These sections are clearly written and make some important points. However, I still have some concerns about the referencing. For example, the issue of lack of trust in primary care doctors (a major problem in China) is simply referenced to the authors' previous 2017 Lancet paper.**

Response: We appreciate this comment. With respect to the referencing issue about lack of trust in primary health care doctors (reasons that patients bypassed primary health care institutions), we directly cited our Lancet review published in 2017, because it was the first time that these findings from the National Primary Health Care Survey (we conducted during 2016 and 2017) were reported. We understand the reviewer's concern, and referred to another study instead (Page 12, Line 199-201).

In a survey covering 17 provinces, the most common reasons that patients bypassed PHC institutions as they need clinical care was poor capacity and skills of the professionals (32%).[11]

5. **In other words, this is not really a paper about the quality of primary care in China. It pays lip service to this in order to act as a vehicle for an extensive section on recommendations for improvement. In a sense there's nothing**

wrong with that and the points made are generally valid and important. However, there is significant overlap with paper 1, with workforce, training and organisational issues common to the problems identified in both papers.

Response: As explained, based on advice from the editor and reviewers, we have combined the papers now particularly focus on quality. Having said that, we respectfully disagree that this review is not about the quality of primary health care in China. The review indeed aimed to provide 'recommendations for improvement', and all the recommendations were about quality of care. To do so, we summarized evidence about the quality of primary health care and the underlying causes. We included evidence from our Lancet paper published in 2017 because it was where the National Primary Health Care Survey was firstly reported, and these findings were essential for us to generate targeted recommendations. In addition, we provided lots of new evidence on quality gaps and analysis on system causes, including GP training, clinical guidelines, coordination and continuity of primary health care.

6. **In my view, neither paper should be published in its present form. I think there might be room for combining the two papers into one, but very significant work would be required.**

Response: As responded above to Comment #1, we combined the two reviews into one that was mainly about quality of primary health care in China.

7. **It's also unfortunate that the literature review (if the paper is to be a review rather than a commentary) will be four years old by the time of publication as a number of relevant papers have been published since then. The first key message (panel 1) that 'there is evidence of widespread gaps in quality' is probably true but poorly justified on the evidence presented in this paper.**

Response: We appreciate this comment. As responded above to Comment #2, we updated the literature search on Dec 30th in this revision, and included more recent evidence, mainly in the section '*Current Quality of China's Primary Health Care*' and '*Challenges in Structure and Process of Primary Health Care System*'. The new references provided evidence on a broader scope of primary health care (communicable and non-communicable diseases, acute and chronic conditions), to demonstrate the widespread gaps.

8. **Alternatively, one could take the view that this paper provides what the title says it is, namely a statement of challenges and recommendations. In that case the paper should not start of by saying "In this review we assess the quality of primary care in China".**

Response: We revised the sentence accordingly (Page 7, Line 58-59).

In this review, we summarize the evidence on quality of PHC in China, analyse the causes for poor quality of care and provide policy recommendations for improvement.

9. **In terms of the paper being a statement of challenges and recommendations, it should be made clear that these are the opinions of the authors rather than being based on evidence. The 6+ pages of recommendations contain only eight references, two of which are to the authors' previous Lancet paper.**

Response: The recommendations are not all based on evaluations of each single one, but they are also not just opinions. The analytical approach that we used for this Review is one that is commonly used in policy research, which follows the following process: 1) problem identification; 2) analysis of underlying causes; 3) policy recommendation for addressing the causes; 4) experimentation of the recommendation or in some cases, direct legislation. In this Review, we summarize the problems that already exist, based on our literature review, rather than doing an original investigation. Then we use the European Primary Care Monitoring System framework to guide us in identifying relevant causes, which led to recommendations. We briefly explained our analytical approach in the third paragraph of "*Introduction*", "*To develop policy recommendations, we also conducted interviews with key stakeholders, front line health workers, and policymakers, as well as evaluations of national and international examples.*"

10. **Some of the recommendations are a bit odd. For example, the section on 'Building a learning primary care system' makes three recommendations: in-service training (fine), decision support tools enhanced by artificial intelligence (really??) and use of big data. Since electronic records are uncommon across the whole of China and many consultations occur with no records at all, this recommendation is, to say the least, aspirational. Indeed, the evidence that decision support tools and big data lead to improvements in primary care even in countries like the UK or US is limited. Maybe this is being a bit picky - the sections on training, integration and accountability are generally good.**

Response: The recommendation about learning health system was indeed an aspiration in future, which we considered a way to strengthen the strategies about workforce education, provider incentives, care integration, and system coordination. Thus, in this revision, we changed the order of our recommendations, in which "Improve information system towards building a learning primary health care system" is the last one following education, accountability, integration and cooperation. We consider it important to mention this recommendation because the government can begin to plan for this possibility.

Also, we added "improve the information system" as a short-term step for reaching the ultimate goal of "a learning health system" (Page 19, Line 384-397).

An integrated electronic health record system per citizen is needed to improve the quality and efficiency in PHC institutions as well as the entire health care system (panel 7). China should address the challenges in the two core information technology (IT) systems in PHC institutions – the Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care.[12] First, clinical IT systems like Electronic Medical Records should be available in all PHC institutions, including village clinics. Second, the development and deployment of clinical IT systems in PHC institutions need to be centralised, with standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care,[13] to ensure integration and interoperability. Third, the Residents Health Record System that was implemented nationwide in the National Basic Public Health Service Program should be integrated with the delivery of clinical care, to ensure that the health data can be used to facilitate appropriate and efficient clinical practice. Fourth, the Electronic Medical Record Systems in PHC should be linked with the ones used in secondary and tertiary hospitals to facilitate patient referrals.

In addition, we added a new panel to introduce experiences on health information technology in primary health care, to improve quality, efficiency, and patient satisfaction (Panel 7, Page 44, Line 807).

In Finland, each of the 5·3 million citizens has a Personal Health Record, which is integrated into a national repository known as the eArchive. These together provide a centralized location for patients, health care providers, pharmacies, and social workers to keep track of patient information, communicate with each another, and make informed clinical decisions. Each patient is listed under a primary health care institution that takes full responsibility for the patient's integrated care, and patients have control over which social workers and health care professionals have access to their information. All patients have secure access to their own records over the Internet using their bank account credentials, mobile identity verification, or an electronic identity card. Patients use the system to fill prescriptions and update their health information in their Personal Health Records with home measurements including blood pressure, peak expiratory flow, blood glucose, diet, and exercise. Electronic communication between professionals and patients is supported by symptom checkers and follow-up forms, secured messages, or real-time chat.

The care is linked to decision-support tools (e.g., guidelines of the most frequent problems encountered in primary health care) and also artificial intelligence that can help practitioners implement guidelines (e.g., the system checks if a medication prescribed by the family physician is compatible with the renal function of the patient and if not, proposes alternatives). In cases of

referral, the information in the Personal Health Record is accessible by the specialist providers.

11. **I liked the box describing how one city, Shenzhen, had gone about systematically improving (its primary care (panel 5) though I don't know whether the Lancet format readily supports a box with text going over more than three A4 sides. Another box (panel 6, hypertension management) also runs to three sides.**

Response: We appreciate this comment. In the Instruction for Authors of the Lancet, we found no length limit for panels. However, we shortened the panel 5 that introduced the National Primary Health Care Hypertension Management Office (Panel 5, Line 37, Page 799). We defer to the journal's police and Editor's decision on whether these panels should be shortened.

~~*In the health care reform of 2009, the National Basic Public Health Service Program was initiated, with hypertension management at primary health care institutions as one of the pillars under sponsorship from the government.85 Nevertheless, barriers at the policy level (omission of quality measurement), organization level (lack of qualified staff, limited availability of antihypertensive drugs), physician level (irrational prescribing), and patient level (low health literacy) all contribute to low disease control across China.5,25,26*~~

~~*Therefore, as a national initiative, the National Health and Family Planning Commission (now the National Health Commission) authorized the National Center for Cardiovascular Diseases to establish t*~~ *The National Primary Health Care Hypertension Management Office was established in March 2017 with the* ~~*. The main*~~ *charge* ~~*of the Office was*~~ *to develop strategies and practices* ~~*ways*~~ *to improve hypertension management nationwide and to serve as a model for other services in the program (see figure below).*

Reviewer #2:

1. **Overall comments: The drivers of gaps in optimal healthcare are well presented, covering incentivisation and poor training opportunities which are indeed major issues.**

Response: We appreciate this comment.

2. **However, the main solution presented mentions is a 'learning system based on digital data and innovative technologies'. Leading with a technological solution does not address the main driver you mention, which are deeper systemic issues. It implies that the authors are giving more attention to the 'hardware'**

of the health system, while the 'software' (motivation of healthcare providers, training, incentives, systems that support integration) are given less importance, even though these relate more directly to the issues mentioned (fee-for-service model that incentivizes testing and treatments irrespective of their clinical necessity; lack of integration between clinical care and public health service; insufficient continuity of care throughout the entire health care system).

Response: We agree that 'software', including training, incentives and integration, should be given more attention to improve the quality of primary health care. Thus in this revision, we changed the order of our recommendations, in which "Enhance the quality of training for new and current primary health care workforce" is the first one, "Establish performance accountability to incentivize high-quality and high-value care" is the second one, "Integrate clinical care with the basic public health services" is the third one, and "Strengthen the coordination between primary health care institutions and hospitals" is the fourth one. "Improve information system towards building a learning primary health care system" is now the last recommendation, which we considered a way to strengthen the strategies about workforce education, provider incentives, care integration, and system coordination.

3. **The executive summary does not make the importance of this article clear - perhaps briefly justify the statement 'now is an opportune time for China to strengthen the quality of its primary health care' - what is special about now? Why will the government act when many of these issues have been well known? Are there political barriers to action?**

Response: We appreciate this comments, and revised the Executive Summary to highlight that after a 10-year reform focusing on investment, the government has increasingly realized the importance of 'improving quality and enhancing efficiency (提质增效)'. This provide an opportune time to implement the recommendations we provided in this manuscript (Page 6, Line 20-31).

> *As part of its health care reform in the past decade, China has significantly increased financial investment and introduced favourable policies for primary health care. However, widespread gaps in the quality still exist, which has contributed to missed opportunities to promote population health. In this review, we aim to identify the causes for poor quality, and provide policy recommendations for improvement. These gaps include suboptimal screening, diagnosis, and treatment of diseases, which compromise health outcomes. System challenges include: suboptimal education and training of primary health care practitioners; a fee-for-service payment system that incentivizes testing and treatments over prevention; fragmentation of clinical care and public health service; insufficient continuity of care throughout the entire health care system. Now is an opportune time for China to strengthen the*

quality of its primary health care as the government is shifting its reform attention to 'improving quality and enhancing efficiency (ti zhi zeng xiao, 提质增效)'.

4. **I would suggest that the executive summary tells the reader what the purpose of the paper is (we assess the quality of primary health care in China, examine the causes for poor quality, and provide policy recommendations for improvement)**

Response: We appreciate this comments and revised the Executive Summary to introduce the purpose of this manuscript as the reviewer suggested (Page 6, Line 23-24).

In this review, we aim to identify the causes for poor quality, and provide policy recommendations for improvement.

5. **The introduction is clearly written. The phrase is 'front line' health workers (not lines).**

Response: We appreciate these comments, and corrected the phrase accordingly (Page 7, Line 66-68).

To develop policy recommendations, we also conducted interviews with key stakeholders, front line health workers, and policymakers, as well as evaluations of national and international examples.

6. **P8: prescribing behaviour - the summary is fine, but the issues mentioned have been document before, and it was shame that factors driving the overprescribing or use of higher cost medicines were not mentioned. Do the papers reviewed indicate drivers such as incentive structures? Why is there an overuse of antibiotics and an underuse of anti-hypertensives, for example?**

Response: We appreciate this comment. We added research evidence about the reasons for primary health care doctors' prescribing behaviour, particularly for overuse of antibiotics (Page 9, Line 99-105) and underuse of anti-hypertensives (Page 9, Line 109-114). This evidence also foreshadowed the section *Challenges in Structure and Process of Primary Health Care System*, in which we analysed deeper causes for poor quality of primary health care.

A 2011 study based on a random sample of PHC institutions in 6 provinces of China also revealed that a quarter of outpatient antibiotics prescriptions and 68% of inpatient antibiotics prescriptions were inappropriate, and improper remuneration incentives was considered a key driver for these prescribing behavior.[3] Moreover, there was a preference of PHC doctors to use broad-

spectrum antibiotics,[4] which is deemed quality issue related to professional incompetence,[5] and could induce the emergence and spread of drug-resistant strains of microbes.[5]

Meanwhile, it found that approximately 8% of medications used were not guideline-recommended,[14] while high-cost medications were more preferentially used than their counterparts that were evidence-based and cheaper.[14-16] These results suggest that in addition to medication supply defect, physicians' knowledge of and willingness to adhere to new hypertension treatment guidelines are issues that need to be addressed.[17]

7. **P9: I found the figures on unlicensed doctors and lack of completion of CME very interesting, and again thought that some mention of reasons for low enforcement of rules would add depth to the paper. Is there any information about why unlicensed doctors are able to practice? Corruption? Fake degrees?**

Response: There are unlicensed doctors practicing in the primary health care institutions, simply due to there are not enough licensed doctors available, particularly in underdeveloped areas. We clarified that in this revision (Page 11, Line 150-152).

Moreover, due to a lack of qualified physicians, more than 20% of doctors practicing in community health centres, township health centres, and community health stations were not licensed (appendix H).[12,18]

8. **P10: Very interesting about how incentive structures changed primary providers clinical behaviour. It points clearly to the need to focus on solutions that are deeper than digital data and technology!**

Response: We agree with this comment and have changed the order of our recommendations, in which "Establish performance accountability to incentivize high-quality and high-value care" is now the second one, and "Improve information system towards building a learning primary health care system" is the fifth. And we discuss incentives as transition from fee-for-service to capitation payment tied with performance as key recommendations for integrated care (Page 16, Line 339-344) and care coordination (Page 19, Line 373-377).

China should consider combining the public health budget with the social health insurance budget and shifting the payment of PHC teams from fee-for-service to a capitation payment method.[19] The capitation payment rate should be risk adjusted and the rate should cover costs for providing health promotion, prevention, management, and clinical care by the PHC physicians and teams. This will encourage PHC physicians to coordinate preventive care with clinical care, thereby leading to better management and better outcomes for the patients.

The aforementioned capitation payment methods should cover services at the primary care level as well as the secondary care hospitals, and eventually be extended to cover tertiary care level. The envisioned primary, secondary, and tertiary care team would jointly manage the capitated funds. If there were savings, they would be shared by the team.

9. **P11: The findings on poor coordination of information systems are very similar to what was found as part of a detailed analysis of China's TB information management system (Optimising routine surveillance systems for informing tuberculosis control policies in China. Health policy and planning 2017, 32:ii12-ii14.) You may consider using this evidence to make the point that poor coordination between information systems - that are well funded and managed separately - seems to be a wider issue.**

Response: We appreciate this comment, and additionally referred to this study in this section (Page 14, Line 238-243).

Similarly for infectious diseases like tuberculosis, complete socio-demographic and clinical information on individuals with presumptive tuberculosis cannot be linked across the Infectious Disease Reporting System and the Tuberculosis Information Management System due to the different identification numbers, even both of which were developed by the China Centers for Disease Control and Prevention (CDC), thus analysis on characteristics of individuals who did not complete the referral are not feasible.[20]

10. **P12: As noted in the comments earlier, I strongly feel that the emphasis on different components of the solution is the wrong way around. Information systems should accompany changes in incentivisation and accountability, not the other way around. Information systems cannot solve the problems documented. If the authors reasons for putting a learning system as the first part of the solution is that more evidence is needed, doesn't that contradict what you have done in the review, which is to clearly lay out the strong evidence for areas that need to be addressed?**

Response: As noted above, we changed the order of our recommendations, in which "Enhance the quality of training for new and current primary health care workforce" is now the first one, "Establish performance accountability to incentivize high-quality and high-value care" is the second one, and "Improve information system towards building a learning primary health care system" is the fifth. And we discuss incentives as transition from fee-for-service to capitation payment tied with performance as key recommendations for integrated care (Page 16, Line 339-344) and care coordination (Page 19, Line 373-377).

China should consider combining the public health budget with the social health insurance budget and shifting the payment of PHC teams from fee-for-service to a capitation payment method.[19] The capitation payment rate should be risk adjusted and the rate should cover costs for providing health promotion, prevention, management, and clinical care by the PHC physicians and teams. This will encourage PHC physicians to coordinate preventive care with clinical care, thereby leading to better management and better outcomes for the patients.

The aforementioned capitation payment methods should cover services at the primary care level as well as the secondary care hospitals, and eventually be extended to cover tertiary care level. The envisioned primary, secondary, and tertiary care team would jointly manage the capitated funds. If there were savings, they would be shared by the team.

11. P13: Just to emphasise, the point suggesting a high performance IT system will be a grand solution only appears naïve, in my opinion. Complex problems around incentive systems and lack of enforcement of licensing requirements will not be fixed with an IT system. For example: ' the system should ensure that professionals are practicing at the top level of their training' - how will an IT system do this if there is not the political will to enforce minimum standards, as can be seen from information you present about CME and licensing?

Response: As responded above, we changed the order of our recommendations in this revision. Now the recommendation about IT system and learning health system is the last one, which we considered a way to strengthen the strategies about workforce education, provider incentives, care integration, and system coordination.

12. P14: What would be the incentives for doctors to spend time on training, when they are concerned about profits?

Response: We agree that the incentives are very important. We additionally discussed that in this recommendation during the revision (Page 16, Line 309-311).

Additionally, incentives would help to motivate PHC doctors to participate the Continuing Medical Education and other in-service training programs, such as providing certifications that are meaningful in their career development and ensuring incomes when they temporarily leave their posts for training.

13. P16: Agree with points made here about medical education

Response: We appreciate this comment.

14. **P17-19: The recommendations make sense, but why have these not been done already? There must be huge political and institutional barriers to enforcing quality control and integration, and these should be considered. Otherwise it becomes a list of solutions that does not consider the challenges to implementing them.**

Response: We appreciate the reviewer's interest in the political and institutional barriers to enforcing quality control and integration. We have been attentive to the feasibility of the recommendations, even though some implementation issues are beyond the scope of this manuscript. With respect to the quality control, the Chinese government historically paid less attention to primary health care. In the National Health Commission (former Ministry of Health, National Health and Family Planning Commission) of China, the Bureau of Medical Administration and the Department of Primary Health should be in charge of quality control for primary health care. However, there are only 3 national policy documents issued during the past decade,[21-23] all of which had focused on prevention of nosocomial infections, but nothing on treatment appropriateness or patient outcomes. Thus, in this manuscript, we highlighted the National Primary Health Care Hypertension Management Office, particularly its responsibility on establishing performance indicators and quality assessment data collection system.

With respect to the integration between clinical care and public health service, the major barrier is different financing mechanisms between them. As we had explained in the section "*Challenges in Structure and Process of Primary Health Care System - Coordination of care*", the package of basic public health services delivered in primary health care institutions is supported by capitated payment directly from the government; while the clinical care is funded by social health insurance and patients' out-of-pocket payments, mostly in a fee-for-service model. In this revision, we emphasized that as the first sentence of the recommendation "Integrate clinical care with the basic public health services" (Page 18, Line 339-341).

> *China should consider combining the public health budget with the social health insurance budget and shifting the payment of PHC teams from fee-for-service to a capitation payment method.*[19]

Reviewer #3: This contribution concerns the structural conditions for primary healthcare in China, focusing on what is needed for high-quality primary care. An existing framework of these conditions is applied for an analysis, which is essentially a set of expert views that is supported by studies. I appreciate that the paper aims to enhance primary healthcare in China, and also the academic work to support this. My comments are made with the intention to improve the manuscript and to increase its value for readers.

Response: We appreciate this comment.

1. **The paper addresses an important topic, which is relevant for China as well as for many other countries (including high-income countries with poor primary healthcare). As I do not have much knowledge of healthcare in China, like probably most readers, it would be helpful to provide some background information and history of the healthcare system. For instance, is it organized universally similar across China or differently in counties/regions? What is the life expectancy and how is the population age structure? How is healthcare, and primary care in particular, funded? What is the typical training of doctors and nurses in primary healthcare? How frequently do people attend a primary care practice (number of visits/ year)? Such information may be provided in box alongside the text, without further discussion.**

Response: We appreciate these comments. We have provided relevant background information about China's primary health care system in the revision, and referred to our 2017 Lancet review. However, given the numbers limits of panels (i.e. box), we added some key background information as the appendixes, including: 1) Phases of development of primary health care in China, including the history of primary health care system (Appendix A);

> *Since the establishment of the People's Republic of China in 1949, its primary health care system has gone through three major phases.*
> *From the 1950s to the 1970s*
> *China received global recognition for its achievements in health improvement and health system development. Its success was particularly notable in the rural areas, where overall health status improved in a relatively short period despite extremely scarce resources. The three-tiered health care delivery system, so-called "barefoot doctors" at village clinics, and low-cost universal health insurance (cooperative medical scheme) were considered the three key elements of its success. The three-tiered health care delivery system in rural areas comprises the clearly defined and well-operated functions of three levels of health providers and organization at the village, township, and county level. In parallel, a similar health care delivery structure was developed in urban areas comprised of three levels of health organizations at the street (now called community), district, and municipal level. China's strategy of focusing on the provision of preventive care and basic curative care at an affordable cost (through insurance coverage and low-cost services) was considered a model of health system development, and the country was intensively involved in the development of the 1978 Alma-Ata Declaration. Core primary health care concepts and policies within the Declaration, including full governmental support, accountability for health, inter-sectorial cooperation on health, affordable health care, education, and a comprehensive development system, were derived from China's successful*

experiences. The context within which China developed its health system was similar to that of many low-income countries, which was a key factor in the acceptance of the Chinese primary health care model by other developing countries when designing their own health systems.

From the 1980s to the early 2000s

The Chinese primary health care system faced challenges as a result of the central government reducing its role in health care financing and insurance organization. Insurance coverage rates under the cooperative medical scheme decreased from 95% in 1976 to 5% in 1985.[24] After several failed attempts to raise funds for health care, the Ministry of Health began emphasizing the importance of self-reliance, and it pursued alternative funding through market-oriented reform.[25] The integrated three-tiered health care delivery system was dismantled as health providers at the village level became privatized, while township-level and county-level hospitals/health centres became self-financing. Preventive care was phased out in favour of the higher revenues provided by curative care. Moreover, hospitals grew in number and scope of services, attracting an increasing number of patients in this competition with the primary health care system.[26,27] Thus the prior advantage in health care efficiency of China, in comparison with other countries with similar levels of development, was gradually losing. Rural health centres, in particular, experienced enormous difficulty under the market-oriented reforms. As the primary health care institutions deteriorated and relied on revenue from user fees, the public health functions of these facilities greatly diminished. During this time, China was widely criticized by both national and international academic and health care organizations for its inability to extend primary health care coverage to all. In its 2000 annual report, WHO ranked China at the bottom fourth of its 191 member states in terms of equitable financial health protection.[28]

From the early 2000s to the present

A policy report commented that "China's health care reform since 1978 was in general a failure".[29] This report, combined with public complaints about health care, were the driving forces behind a new phase of system reform. The government began to re-establish the rural health insurance system in 2003 and the urban resident health insurance system in 2007. A more comprehensive reform agenda, developed by a number of line ministries with technical support from academic institutions, was implemented in 2009. Since then, strong primary health care has been a key strategy of health care reform in addition to universal health insurance coverage, a National Essential Medicines System, and basic public health services. The government increased its subsidies to primary health care institutions from 19 billion RMB in 2008 to 197 billion RMB in 2018.[26,30] Acknowledging the increasing pressure exerted by an aging population, behavioural changes,[31] and rapid urbanization,[32] the Healthy China 2030 plan issued in 2016 envisions the

primary health care system as a means of addressing the emerging dual burden of chronic NCDs and increasing health expenditures.[33]

2) Institutions providing primary health care (Appendix B);

In 2015, the Chinese State Council issued the Plan for the Health Care Delivery System (2015–2020), in which various health care organisations and their functions were defined.[34] *The primary health care system in China is divided into urban and rural components, each with a two-tier structure. Most of the institutions in this system are publicly owned (i.e., the institutions are owned by all or a specific group of Chinese citizens).*[26,27] *In 2018, urban components included approximately 9300 community health centres and, one level below them, 25 600 community health stations. Rural components included approximately 36 400 township health centres and, one level below them, 622 000 village clinics.*[26]

In addition to the four types of care institutions above, there are about 228 000 community clinics (96% privately owned), 21 600 clinics belonging to individual organisations such as schools and companies (34% privately owned),[27] *and many community pharmacies (most privately owned). The community clinics mainly provide medical care in specific fields such as dental disorders or traditional Chinese medicine (TCM). The clinics belonging to organisations provide health care services only to employees or students of the organisation. These clinics and pharmacies are important parts of clinical care delivery, as they supplement the primary health care system. Moreover, a growing number of private health management companies scattered in large cities are providing medical examination, disease screening, and outpatient services too.*

3) Primary health care professionals and their training (Appendix H);

Primary health care requires multidisciplinary professional teams that consist of doctors, nurses, pharmacists, and other health workers. Different types of primary health care professionals, and the synergy between them, are crucial for the system to provide comprehensive and high-quality services. In 2018, the primary health care workforce consisted of approximately 1 310 000 physicians, 907 000 village doctors, 852 000 nurses, 147 000 pharmacists, and 106 000 technicians.[26,27] *As the backbone of the workforce, primary health care physicians and village doctors in China have a unique portfolio in comparison with other countries. There were 471 000 licensed physicians or licensed assistant physicians in urban areas, and 834 000 licensed physicians or licensed assistant physicians in addition to 907 000 village doctors in rural areas.*[26,27] *It takes 5 years of medical education after 12 years of primary and secondary education to become a licensed physician or 3 years of medical education after 12 years of primary and secondary education to become a*

licensed assistant physician, and regular and assistant physicians must pass the national practicing doctor (or assistant doctor) examination and periodic government assessments to maintain their licenses.

It is worth noting that most physicians in China have not been trained to be, or qualify as, general practitioner as it is defined in many other countries, since the development of China's general practitioner training system began in 2011. Village doctors need only a technical school education (3 years of medical education after 9 years of primary and secondary education) or 20 years of continuous practicing experience to work in village clinics. Village doctors practice with a village doctor certificate, rather than a regular license, and cannot practice in other types of health care institutions.

4) Evolution of the National Basic Public Health Service Program (Appendix D);

Year	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***
Funding, Yuan per capita	*15*	*15*	*25*	*25*	*30*	*35*	*40*	*45*	*50*
Residents' health records	√	√	√	√	√	√	√	√	√
Health education	√	√	√	√	√	√	√	√	√
Child health management	√	√	√	√	√	√	√	√	√
Maternal health care	√	√	√	√	√	√	√	√	√
Elderly health management	√	√	√	√	√	√	√	√	√
Vaccination	√	√	√	√	√	√	√	√	√
Reporting of infectious diseases and public health emergencies	√	√	√	√	√	√	√	√	√
Health management for hypertension	√	√	√	√	√	√	√	√	√
Health management for type-2 diabetes	√	√	√	√	√	√	√	√	√
Health management for psychosis	√	√	√	√	√	√	√	√	√
Health supervision	–	–	√	√	√	√	√	√	√
Traditional Chinese medicine health management	–	–	–	–	√	√	√	√	√
Health management for tuberculosis	–	–	–	–	–	–	√	√	√
Contraceptive device	–	–	–	–	–	–	–	–	√
Health promotion	–	–	–	–	–	–	–	–	√

5) The scope of the clinical care provided in primary health care institutions (Appendix E).

To understand the scope of the clinical care provided in primary health care institutions in China, we asked the 10,626 primary health care physicians and village doctors involved in our survey to identify the top five clinical conditions that they encounter in regular practice. In community health centres and community health stations, the most commonly identified conditions were common cold (14·5% and 19·1%, respectively), followed by hypertension (11·0% and 11·5%), diabetes (9·6% and 9·0%), chronic

bronchitis (8·7% and 8·6%), and acute bronchitis (8·1% and 8·6%). Doctors at township health centres and village clinics identified common cold (13·6% and 19·5%, respectively), acute bronchitis (9·0% and 10·7%), and chronic bronchitis (8·5% and 10·5); however, they more often identified gastritis (7·5% and 10·3%) and diarrhea (5·3% and 11·7%) than hypertension (7·9% and 9·8%) and diabetes (4·6% and 4·6%).

Clinical conditions	Community health center	Community health station	Township health center	Village clinics
Cold	14.5%	19.1%	13.6%	19.5%
Hypertension	11.0%	11.5%	7.9%	9.8%
Diabetes mellitus	9.6%	9.0%	4.6%	4.6%
Chronic bronchitis	8.7%	8.6%	8.5%	10.5%
Acute bronchitis	8.1%	8.6%	9.0%	10.7%
Gastritis	6.5%	8.4%	7.5%	10.3%
Diarrhea	4.5%	6.7%	5.3%	11.7%
Urinary tract infection	4.1%	3.1%	4.5%	2.9%
Osteoarthritis	3.0%	2.3%	2.4%	0.5%
Low back pain	2.8%	1.5%	2.5%	0.8%
Psoatic strain	2.7%	2.3%	2.6%	0.8%
Peptic ulcer	2.1%	2.0%	2.9%	1.7%
General trauma	2.0%	1.3%	3.1%	1.1%
Sciatica	2.0%	0.6%	1.8%	0.3%
Child dyspepsia	2.0%	4.4%	3.2%	7.0%
Pelvic inflammatory disease	1.9%	0.4%	2.7%	0.6%
Vaginitis	1.8%	0.4%	2.7%	0.5%
Dysmenorrhoea	1.7%	1.2%	2.3%	0.5%
Cholecystitis	1.6%	1.4%	2.6%	1.6%
Toothache	1.5%	3.6%	1.3%	2.7%
Menopausal syndrome	1.4%	0.2%	1.4%	0.1%
Cholelithiasis	1.0%	0.5%	1.6%	0.4%
Idiopathic headache	0.8%	0.6%	0.6%	0.2%
Haemorrhoids	0.7%	0.5%	1.1%	0.4%
Asthma	0.6%	0.1%	0.6%	0.2%
Chronic dermatitis	0.5%	0.3%	0.2%	0.1%
Tympanitis	0.5%	0.4%	0.7%	0.2%
Conjunctivitis	0.5%	0.3%	0.6%	0.1%
Purulent skin infection	0.4%	0.1%	0.5%	0.0%
Sinusitis	0.4%	0.5%	0.6%	0.3%
Convulsion in children	0.3%	0.0%	0.3%	0.0%

For other background information, including the financing and governance of primary health care system in China, we cited our Lancet review in 2017.

2. **The paper has many authors, which may explain the patch-work character of the document and the variable analytical depth and variable reference to studies for specific claims. If there has been no reference to studies for a specific claim provided, it is unclear whether such studies are not available or not cited. The paper mixes factual information, assessment (in terms for good/bad) and recommendations for policy makers. General recommendations are: a) To provide reference to studies to support claims in factual statements, or state explicitly that the claim is based on expert views. Alternatively, it may be stated upfront that all claims are expert-based except if stated otherwise.**

Response: We assume the reviewer was talking about the section *Challenges in Structure and Process of Primary Health Care System*, since this section included both prior evidence and our explanations. We identified three claims with no prior evidence to support in this section, and revised according to the reviewer's suggestions: 1) lack of integration between clinical care and public health services – we clarified that they are based on expert view, and added a reference about tuberculosis management information technology systems (Page 13, Line 229-243).

> *Second, there is almost no coordination in monitoring, performance measurement, or management between the two programs. Thus, as we observed as both researchers and practitioners, there is little workflow interaction or information sharing between the two. For instance, in hypertension management visits under the National Basic Public Health Service Program, patients can have blood pressure measurement and lifestyle consultations by public health workers, but cannot get antihypertensive prescriptions without attending the clinics. Also, resident health records on public health services and medical records on clinical care are kept by two separate information systems even for the same visit of the same patient and there is no linkage between them. The poor care coordination is a hindrance particularly to managing NCDs. Similarly for infectious diseases like tuberculosis, complete socio-demographic and clinical information on individuals with presumptive tuberculosis cannot be linked across the Infectious Disease Reporting System and the Tuberculosis Information Management System due to the different identification numbers, even both of which were developed by the China Centers for Disease Control and Prevention (CDC), thus analysis on characteristics of individuals who did not complete the referral are not feasible.*[20]

2) inadequate informational continuity throughout primary health care system – we cited our paper published in Lancet in 2017 that reported the relevant findings from National Primary Health Care Survey (Page 15, Line 261-267).

Second, there is inadequate 'informational continuity' throughout the system. The electronic medical record system in PHC institutions is still commonly unavailable, fragmented, and isolated in its ability to integrate and analyse comprehensive information about individual patients.[12] The establishment of the centralised resident health record system in the National Basic Public Health Service Program for the entire catchment populations potentially places PHC services in a position to take a cradle-to-grave approach to managing health care. However, the potential to use these data goes unfulfilled.

3) poor managerial continuity because primary health care institutions and hospitals are financed, governed, and managed separately – we cited a report *People's Republic of China health system review* to support that (Page 15, Line 268-272).

Third, with respect to 'managerial continuity', because PHC institutions and hospitals are financed, governed, and managed separately,[35] there are barriers to ensuring consistency, coordination, and quality of care across sites of care..

3. b) I would favour a clearer distinction between factual information and recommendations, rather than mixing these in the text, but this is obviously an editorial decision.

Response: We assume this comment was about the sixth paragraph in the recommendation "Build a learning primary health care system", in which we summarized the findings from National Primary Health Care Survey about use of IT systems in primary health care institutions (i.e. IT systems for clinical care often unavailable and not interoperable, in the meantime, IT systems for public health service are rarely leveraged in clinical practice). In this revision, we removed this evidence, and provided specific recommendations instead to address these deficits (Page 19, Line 385-397).

China should address the challenges in the two core information technology (IT) systems in PHC institutions – the Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care.[12] First, clinical IT systems like Electronic Medical Records should be available in all PHC institutions, including village clinics. Second, the development and deployment of clinical IT systems in PHC institutions need to be centralised, with standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care,[13] to ensure integration and interoperability. Third, the Residents Health Record System that was implemented nationwide in the National Basic Public Health Service Program should be integrated with the

delivery of clinical care, to ensure that the health data can be used to facilitate appropriate and efficient clinical practice. Fourth, the Electronic Medical Record Systems in PHC should be linked with the ones used in secondary and tertiary hospitals to facilitate patient referrals.

4. **P.9 This is a framework-guided policy analysis, but the methods could be specified in some more detail. Such information on the methods would be required, even for a narrative review.**

Response: The analytical approach that we used for this Review is one that is commonly used in policy research, which follows the following process: 1) problem identification; 2) analysis of underlying causes; 3) policy recommendation for addressing the causes; 4) experimentation of the recommendation. In this Review, we summarize the problems that already exist, based on our literature review, rather than doing an original investigation. Then we use the European Primary Care Monitoring System framework to guide us in identifying relevant causes, which led to recommendations. We briefly explained our analytical approach in the third paragraph of "*Introduction*", "*To develop policy recommendations, we also conducted interviews with key stakeholders, front line health workers, and policymakers, as well as evaluations of national and international examples.*"
Moreover, The Chinese government can take some of these recommendations forward by piloting first, which we have added, "*These recommendations could guide China's action plans in terms of policy formulation and designing pilots to test the recommendations' effects and feasibility.*" (line 288-290)

5. **P.10-11 The section on actual quality of primary care is rather short and does not convincingly convey the message that quality of primary care is suboptimal in China. If the number of studies is really limited, it may be possible to use specific population metrics (e.g. number of hospital admissions, infection rates, etc.) as proxy indicators for quality of primary care. The OECD health program may be a helpful source of indicators.**

Response: We appreciate this comment. We updated the literature search on Dec 30th in this revision and included more recent evidence about the quality of primary health care in China (Page 8, Line 91-95).

In another study using incognito standardized patient with classic pulmonary tuberculosis symptoms, correct management proportions at township health centres (38%) and village clinics (28%) were significantly lower than at county hospitals (90%).[1] There is a significant variation of observed doctors' behaviour within each group (township health centres or village clinics) as well,[1] which was similar in other middle-income countries.[2]

(Page 10, Line 126-133).

> *For diabetes, a nationally representative survey in 2013 of 170,287 Chinese participants found that only 37% of those with diabetes were aware of their diagnosis, and just 32% were being treated.[6] Another nationwide longitudinal survey from 2011 to 2015 identified a decrease in health education coverage (from 76% to 70%) and persisted gaps in use of examinations and treatments (from 79% to 81%), accompanied by an increase in both diabetes-related hospital admission (from 4% to 6%) and readmission (from 19 to 28%).[7] China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).[8].*

We agree that international comparison could be useful. Thus we conducted targeted search for studies in China that focused on OECD quality indicators of primary care (https://www.oecd.org/els/health-systems/hcqi-primary-care.htm). We added the finding on hypertension and diabetes hospital admission rate in this revision (Page 9, Line 121-123), which clearly demonstrated that quality of primary health care in China is suboptimal.

> *Under-performance of PHC may explain China's much higher hypertension hospital admission rate (490 per 100 000 population) compared with all OECD countries (average at 95 per 100 000 population).[8,36]*

(Page 10, Line 132-133)

> *China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).[8]*

6. **P.15. Given the current situation, the recommendations in the section 'Build a learning primary care system' seem to refer to a rather distant future. A 'learning platform for evidence generation and training, as well as performance monitoring and promoting' is not something that many other countries have established. The emphasis and elaboration on IT systems is striking. In my experience, primary healthcare is first and most-dependent on competent and motivated health professionals (doctors and nurses). I would recommend to add some short-term, feasible steps for reaching the ultimate goals.**

Response: We agree that quality of primary health care first and most dependent on competent and motivated health professionals, and a true learning health system is not something that many countries have established. Thus in this revision, we changed the order of our recommendations, in which "Enhance the quality of training for new and current primary health care workforce" is now the first one, "Establish performance

accountability to incentivize high-quality and high-value care" is the second one, and "Improve information system towards building a learning primary health care system" is the fifth. Also, as the reviewer recommended, we added "improve the information system" as a short-term step for reaching the ultimate goal of "a learning health system" (Page 19, Line 384-397).

> *An integrated electronic health record system per citizen is needed to improve the quality and efficiency in PHC institutions as well as the entire health care system (panel 7). China should address the challenges in the two core information technology (IT) systems in PHC institutions – the Residents Health Record System for basic public health services and the Electronic Medical Record System for clinical care.[12] First, clinical IT systems like Electronic Medical Records should be available in all PHC institutions, including village clinics. Second, the development and deployment of clinical IT systems in PHC institutions need to be centralised, with standardised data structures, definitions, use of appropriate classification systems such as International Classification of Primary Care,[13] to ensure integration and interoperability. Third, the Residents Health Record System that was implemented nationwide in the National Basic Public Health Service Program should be integrated with the delivery of clinical care, to ensure that the health data can be used to facilitate appropriate and efficient clinical practice. Fourth, the Electronic Medical Record Systems in PHC should be linked with the ones used in secondary and tertiary hospitals to facilitate patient referrals.*

In addition, we added a new panel to introduce experiences on health information technology in primary health care, to improve quality, efficiency, and patient satisfaction (Panel 7).

> *In Finland, each of the 5·3 million citizens has a Personal Health Record, which is integrated into a national repository known as the eArchive. These together provide a centralized location for patients, health care providers, pharmacies, and social workers to keep track of patient information, communicate with each another, and make informed clinical decisions. Each patient is listed under a primary health care institution that takes full responsibility for the patient's integrated care, and patients have control over which social workers and health care professionals have access to their information. All patients have secure access to their own records over the Internet using their bank account credentials, mobile identity verification, or an electronic identity card. Patients use the system to fill prescriptions and update their health information in their Personal Health Records with home measurements including blood pressure, peak expiratory flow, blood glucose, diet, and exercise. Electronic communication between professionals and*

patients is supported by symptom checkers and follow-up forms, secured messages, or real-time chat.
The care is linked to decision-support tools (e.g., guidelines of the most frequent problems encountered in primary health care) and also artificial intelligence that can help practitioners implement guidelines (e.g., the system checks if a medication prescribed by the family physician is compatible with the renal function of the patient and if not, proposes alternatives). In cases of referral, the information in the Personal Health Record is accessible by the specialist providers.

7. **p.18 The section on training the primary care workforce is limited, superficial and partly relates to medical training generally. Also, it is only focused on physicians, ignoring the role nurses in primary care. Overall, this is the weakest section of the document although arguably, it concerns the most important aspect of primary healthcare. As it stands, the paper focuses on 'systems' and less on 'people', which matches with a public health/health systems perspective.**

Response: We appreciate this comment, then put the recommendation on workforce training first in the section "*Recommendations for Improvement*" and strengthen it in three aspects. First, we acknowledged the importance of nurses training, and supported nurse practitioner idea that was proposed in a recent Commentary in the Lancet (Page 17, Line 312-317).

> *In addition to doctors, the key role of nurses and other health workers in PHC should be recognized and promoted. Specifically, recent pilot projects on nurse practitioner training, including those that accept new graduates with bachelor degrees from School of Nursing in medical colleges, and others that assign mid-career nurses to practise in PHC institution, could be considered a promising way to strengthen PHC workforce, particularly for chronic diseases management.*[37]

Second, we added recommendation about non-clinical skill training for general practitioners (Page 16, Line 294-296).

> *Increasingly training should prepare them to work in multi-professional teams, and emphasis should be placed on the importance of doctor-patient communication, for example, empathy and shared decision-making, in building trust between patients and PHC providers.*

Third, we additionally proposed strategies to increase professional appeal for medical students and develop incentives for in-service workforce (Page 16, Line 296-300).

Third, the government could also consider setting targets for the percentage of medical graduates who would pursue post-graduate training in general practice,[38] and develop strategies for inspiring students to work in PHC, like exposing undergraduate medical students to PHC and community health service early in the curriculum.[39]

(Page 16, Line 296-300).

Additionally, incentives would help to motivate PHC doctors to participate the Continuing Medical Education and other in-service training programs, such as providing certifications that are meaningful in their career development and ensuring incomes when they temporarily leave their posts for training.

8. **P.19 The recommendation to integrate primary care with public health seems to me one of several options to enhance primary care in China. The overlap between public health (e.g. preventive services, health promotion) and primary health care (=mainly diagnosis and treatment of individual patients) is limited. In other countries, primary care has developed historically in different ways. In a review paper like this, I would expect that different options are presented and discussed in terms of advantages and disadvantages. In my experience, decision makers want to have options listed and elaborated, not one single recommended approach.**

Response: We respectfully disagree that the overlap between public health service and primary health care is limited. For 'primary care', similar with secondary or tertiary care, it is mainly about diagnosis and treatment for individuals. However 'primary health care', since the Declaration of Alma Ata,[40] has included preventive care and health promotion.[41,42]

We agree that in other countries, primary care has developed historically in different ways. But in many continents, actually the countries are integrating primary care and public health services at grassroots level, considering the importance of addressing social and environmental determinants of health.

For China, we recommended integration between clinical care (primary care) and public health services in primary health care system, because this system provided a unique foundation for basic public health services to outreach to remote areas and vulnerable groups in such a vast country. Since the health care reform in 2009, China prioritised infrastructure development of primary health care system to provide equal services to all its population.[43] The National Health Services Survey in 2013 found that 92% of households across the country could reach a health care facility (mostly primary health care institutions) within 20 minutes.[44] Even in the most underdeveloped areas of China, 88% townships and 83% villages had established a

standardized township health centre or standardized village clinic by the end of 2018, and the figures are expected to reach 100% before 2020.[45]

9. **p.21 The text of quality improvement takes a systems perspective, neglecting the role of healthcare professionals in this context. Overall, it seems a bit early to focus on quality improvement as primary care first needs to be developed at sufficient capacity and competence before its quality can be further enhanced. Nevertheless, it seems fine to include a section on the topic.**

Response: We agree that primary health care first needs to be developed at sufficient capacity and competence. However, we do not agree that capacity building should be done "before" quality can be further enhanced separately – instead, we consider the capacity building an essential, and maybe the most important part in enhancing the quality. Thus, in this revision we put the recommendation on workforce training first in the section "*Recommendations for Improvement*", and strengthen it in several aspects, as responded above to.

10. **p. 22 The paper may be further strengthened by relating the development of primary care in China to its development in other countries, particularly those with a relatively weak primary care system and a substantial body of research on the topic (e.g. United States and Germany).**

Response: We appreciate and agree with this comment. According to international standards the primary health care system in China as it functions nowadays, with limited gatekeeping function, should be defined as weak. We added the comparison in primary care quality indictors (i.e. hypertension and diabetes hospital admission rates) between China and OECD countries including USA and Germany (Page 9, Line 121-123).

> *Under-performance of PHC may explain China's much higher hypertension hospital admission rate (490 per 100 000 population) compared with all OECD countries (average at 95 per 100 000 population).*[8,36]

(Page 10, Line 132-133)

> *China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).*[8]

11. **Figures and tables. Relatively many relate to cardiovascular disease, more particularly hypertension. This may be due to the composition of the author team, which involves many in this field. Primary care is obviously much broader and it would be desirable to reflect this in the examples used.**

Response: We agree that primary health care covers a much broader scope of service and intended to include all available evidence on quality of primary health care for different health conditions. However, in the comprehensive literature search, there was few studies on issues other than use of antibiotics and management for hypertension. Nevertheless, we updated the literature search in this revision, and added examples about a multicenter study using incognito standardized patient with classic pulmonary tuberculosis symptoms, and a nationwide longitudinal survey on diabetes care, as the reviewer suggested (Page 8, Line 91-95).

> *In another study using incognito standardized patient with classic pulmonary tuberculosis symptoms, correct management proportions at township health centres (38%) and village clinics (28%) were significantly lower than at county hospitals (90%).[1] There is a significant variation of observed doctors' behaviour within each group (township health centres or village clinics) as well,[1] which was similar in other middle-income countries.[2]*

(Page 10, Line 126-133).

> *For diabetes, a nationally representative survey in 2013 of 170,287 Chinese participants found that only 37% of those with diabetes were aware of their diagnosis, and just 32% were being treated.[6] Another nationwide longitudinal survey from 2011 to 2015 identified a decrease in health education coverage (from 76% to 70%) and persisted gaps in use of examinations and treatments (from 79% to 81%), accompanied by an increase in both diabetes-related hospital admission (from 4% to 6%) and readmission (from 19 to 28%).[7] China's diabetes hospital admission rate had reached 260 per 100 000 population, which was much higher than most OECD countries (average at 141 per 100 000 population).[8].*

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