

Status and Influential Factors of Intelligent Healthcare in Nursing Homes in China

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With the support of the Chinese government, nursing homes have increasingly adopted Internet and intelligent information technology to provide daily healthcare services to residents. However, no research has reported the status of intelligent healthcare in nursing homes. From September 2017 to May 2018, we conducted a survey of 197 nursing homes and collected information on their general characteristics, the intelligent healthcare services provided, the effectiveness of the application products used, and the attitudes of the staff and residents toward intelligent healthcare. Overall, 79.69% of the surveyed nursing homes have provided intelligent healthcare services, including medical care services (eg, chronic disease management and intelligent nursing) and daily life services (eg, fall monitoring and wireless positioning). Portable health monitoring devices and data management and service platforms are the most used healthcare products. The attitudes of staff probably affected the development of intelligent healthcare. Financial investment and the attitudes of staff and residents are factors that influence the effectiveness of the application of intelligent healthcare products in nursing homes. With the support of national policies, nursing homes have implemented primary intelligent healthcare. Stakeholders play pivotal roles in the provision of intelligent healthcare services.

KEY WORDS: Intelligent healthcare, Nursing homes, Application, Aging, Service

Population aging is a worldwide phenomenon that poses significant challenges to society and economic sustainability.^{1,2} At present, China has the largest number of older adults in the world. The data from National Bureau of Statistics of China show that China has a population of 1395 million, with 249 million aged 60 years or older, accounting for 17.9% of the total population in 2018.³ Further, the number of older adults aged more than 80 years reached 29 million.⁴

For older adults, two types of healthcare services should be given the highest priority. On the one hand, medical care service is necessary because older adults commonly have chronic diseases or age-related disabilities.⁵⁻⁷ On the other hand, daily life care service is urgently needed to mitigate inconveniences resulting from the decline of physiological function among older adults.⁸⁻¹² Provision of high-quality healthcare services to meet the demands of older adults became a pivotal topic in the aging process of both China and other countries all over the world.

Studies have mentioned that smart healthcare products could effectively reduce accidents among older adults, reduce medical costs, reduce the health service costs, and improve management effectiveness. A South Korean study confirmed the potential benefits of improving treatment continuity in Korean adults with type 2 diabetes mellitus using a chronic disease care system.¹³ Mainstream products with embedded wearable technology and nursing functions, like smart watches and smart phones, provide effective monitoring and alarm systems for the care of older adults, which can mitigate the occurrence of adverse unexpected events such as falls.¹⁴ The application of a remote monitoring system for the management of chronic diseases enabled healthcare providers to conduct remote medical interaction with patients instead of a direct face-to-face medical examination, effectively reducing healthcare costs.²

In 2015, China enacted a national policy “State Council’s Guidance on Actively Promoting ‘Internet Plus’ Action,” and this guideline defines intelligent healthcare as the application of intelligent health products, information platforms, network technology, intelligent control technology, communication technology, cloud computing, big data, and service technology to provide professional nursing care, health management, rehabilitation care, health monitoring, health risk assessment, reminders and timely warnings, and other healthcare

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services.¹⁵ In 2017, the Ministry of Industry and Information Technology, the Ministry of Civil Affairs, and the Health Planning Commission jointly issued the “Smart Health and Aged Industry Development Action Plan (2017–2020),” which prioritized continuous innovation and application of smart healthcare products and promoted intelligent healthcare in nursing homes.¹⁶ These smart healthcare products are designed to enable older adults to better cope with difficulties and inconveniences and to maintain healthier, more independent, more comfortable, and more active lives.¹⁷

Overall, with the support of the national policy, a considerable number of domestic nursing homes have tried to provide intelligent healthcare service to enhance the quality and effectiveness of healthcare services. However, no study has explored the status of the development of intelligent healthcare in nursing homes in China. Therefore, we conducted a cross-sectional study to explore the current status of intelligent healthcare and its related influential factors.

METHODS

Questionnaire

A questionnaire on intelligent healthcare service in nursing homes in China was designed, and a pilot questionnaire survey was carried out before self-designed questionnaire was finally adopted with adjustments and improvements. The questionnaire included items on the general characteristics of nursing homes, intelligent healthcare services, the intelligent healthcare products applied, the attitudes of the staff and residents toward intelligent healthcare, the development of intelligent healthcare, and the effectiveness of the application of intelligent products. The general characteristics of nursing homes include their regional distribution, number of beds and occupancy rate, types of older people served in terms of their self-care ability, and proportion of the total budget that is dedicated to financial investment in intelligent healthcare. According to the policy of the seventh Five-Year Plan, Chinese provincial administrative regions are divided into West, Central, and East, which is the classification used to identify the regional distribution of the nursing homes. Sizes and occupancy rate were also investigated to explore their impact on intelligent healthcare. Occupancy rate refers to the ratio of residents to the total number of beds, which was divided into four levels ($\leq 25\%$, $25\%–50\%$, $50\%–75\%$, and $>75\%$). Number of beds in the nursing home was classified into three levels (≤ 200 , $200–500$, and >500). The nursing homes were categorized into two types according to the self-care ability of residents: one housing only older adults with self-care ability, and the other housing older adults with or without self-care ability. The application effectiveness of the products and the level of development of intelligent healthcare were evaluated by administrators of the nursing

homes on a scale of 10; scores of 1 to 5 were classified as bad, and 6 to 10 as good.

Participants Surveyed

Convenience sampling was conducted from 2017 to 2018 among administrators of nursing homes who participated in “National Training Courses for Directors of Nursing Homes” organized by the China Association of Social Welfare and Senior Service.¹⁸ The China Association of Social Welfare and Senior Service is responsible for providing regular healthcare training courses for staff members of the accredited nursing homes. The investigators (graduate students) were trained to conduct the survey with the coordination of the working personnel of the China Association of Social Welfare and Senior Service through face-to-face interviews. The sample elimination criteria included (1) questionnaires finished by nonmanagement personnel of the nursing homes and (2) questionnaires without key data on intelligent healthcare provision or other key variables.

Statistical Approach

Data were analyzed using IBM SPSS Statistics version 22.0 (IBM, Armonk, NY). Comparisons were tested using the χ^2 test analysis for categorical variables and analysis of variance for continuous variables. Statistical significance was defined as $P < .05$ and 95% confidence intervals (CIs) were calculated. Binary logistic regression analysis was conducted to estimate the association of covariates and development of intelligent healthcare services in nursing homes.

RESULTS

General Characteristics of the Nursing Homes and Factors Associated With Intelligent Healthcare Provision

In total, 197 nursing homes were surveyed in this study, including 114 in the eastern region, 39 in the central region, and 44 in the western region of China. Most (79.69%, $n = 157$) of the nursing homes have provided intelligent healthcare service, with the highest proportion (61.15%, $n = 96$) found in the eastern region of China. Attitudes of the staff to providing intelligent healthcare ($P < .01$) and residents' receptiveness to intelligent healthcare ($P < .01$) were associated with the provision of intelligent healthcare in nursing homes (Table 1).

A binary logistic analysis showed that the attitudes of the staff in nursing homes to intelligent healthcare ($P < .01$) and residents' receptiveness to intelligent healthcare were influential factors. The agreement of staff on intelligent healthcare was positively correlated with intelligent healthcare provision in nursing homes (agree vs disagree: odds ratio [OR], 15.686; 95% CI, 3.657–67.289). Additionally, higher proportion of residents favoring intelligent healthcare was positively correlated with the provision of intelligent healthcare in nursing homes (high vs low: OR, 10.377; 95% CI, 1.131–95.19) (Table 2).

Table 1. Characteristics of the Nursing Homes Related to the Provision of IH (N = 197)

Characteristics	Provision of IH		
	No (n = 40)	Yes (n = 157)	P Value
Regional distribution of nursing homes			
West	12 (30%)	32 (20.38%)	.179
Central	10 (25%)	29 (18.47%)	
East	18 (45%)	96 (61.15%)	
Occupancy rate			
≤25%	5 (12.5%)	22 (14.01%)	.900
25%–50%	8 (20%)	39 (24.84%)	
50%–75%	9 (22.5%)	33 (21.02%)	
>75%	18 (45%)	63 (40.13%)	
Number of beds			
≤200	12 (30%)	38 (24.2%)	.189
200–500	11 (27.5%)	68 (43.31%)	
>500	17 (42.5%)	51 (32.49%)	
Types of residents served			
Only healthy	6 (15%)	23 (14.6%)	.955
All types	34 (85%)	134 (85.4%)	
Ownership			
Government	11 (27.5%)	43 (27.39%)	.747
Nonprofit	8 (20%)	40 (25.48%)	
For profit	21 (52.5%)	74 (47.13%)	
Financial investment in IH			
Low (≤10%)	20 (50%)	77 (49.04%)	.941
Middle (10%–30%)	15 (37.5%)	57 (36.31%)	
High (>30%)	5 (12.5%)	23 (14.65%)	
Attitudes of staff to IH			
Disagree	38 (95%)	86 (54.8%)	<.001
Agree	2 (5%)	71 (45.2%)	
Proportion of residents favoring IH			
Low (<50%)	39 (97.5%)	91 (57.96%)	<.001
High (≥50%)	1 (2.5%)	66 (42.04%)	
Comprehension of IH			
Yes	7 (17.5%)	14 (8.92%)	.203
Vaguely	21 (52.5%)	79 (50.32%)	
No	12 (30%)	64 (40.76%)	

Abbreviation: IH, intelligent healthcare.

As for the development of intelligent healthcare in the nursing homes, the main restrictive factors self-reported by the administrators of nursing homes included lack of financial investment, residents' low acceptance rate of intelligent healthcare, and lack of intelligent technical management personnel.

Status of Intelligent Healthcare in Nursing Homes

A further analysis of the 157 nursing homes that provide intelligent healthcare services revealed that the key healthcare services included intelligent chronic disease management, intelligent life services, intelligent building facilities, intelligent nursing, and intelligent property management (Figure 1).

Further, the most prevalent smart healthcare products used in these nursing homes were portable health monitoring devices, data management and service platforms, intelligent nursing devices, self-service health testing devices, and smart robots (Figure 2). In the portable health monitoring devices, the top three most commonly used were portable sphygmomanometers, finger-clip oxygen saturation monitors, and wristband blood-glucose testers. Among intelligent nursing devices, smart mattresses, intelligent monitoring beds, and smart wheelchairs were popular.

The top three health services provided to the residents in nursing homes focused on medical care (eg, chronic diseases

Table 2. Binary Logistic Analysis of the Influential Factors on the Provision of IH in Nursing Homes in China (N = 197)

Characteristic	OR (95% CI)	P Value
Attitudes of staff to IH		
Disagree	1 (reference)	
Agree	15.686 (3.65–67.289)	<.001
Proportion of residents favoring IH		
Low (<50%)	1 (reference)	
High (≥50%)	10.377 (1.131–95.19)	.039

Abbreviations: IH, intelligent healthcare; OR, odds ratio.

management and online health advisory) and life care services. Further, chronic diseases management service mainly consisted of health record management, condition monitoring, and personalized health evaluation. Fall monitoring and wireless positioning were found to be the key components of life care services (Figure 3).

Evaluation of Intelligent Healthcare Provision in Nursing Homes

The provision of intelligent healthcare in nursing homes was evaluated through the level of development and the effectiveness of intelligent healthcare products. Among the 157 nursing homes providing intelligent healthcare, 29.9% (n = 47) reported good development and 34.3% (n = 54) reported good effectiveness of the application of intelligent health products. A single factor analysis showed that the financial investment and attitudes of the staff concerning intelligent healthcare were associated with the level of development. The financial investment, attitudes of the staff concerning intelligent healthcare, and the proportion of residents favoring intelligent healthcare were associated with the effectiveness of intelligent healthcare products (Table 3).

A binary logistic analysis showed that the attitudes of the staff influenced the level of development of intelligent healthcare in the nursing homes (agree vs disagree: OR, 2.97; 95% CI, 1.461–6.038). Factors influencing the effectiveness of intelligent healthcare services in nursing homes included financial investment (high vs low: OR, 6.514; 95% CI, 2.310–18.136), attitudes of the staff (agree vs disagree: OR, 3.428; 95% CI, 1.72–6.835), and residents' receptiveness to intelligent healthcare (high vs low: OR, 3.333; 95% CI, 1.679–6.619) (Table 4).

DISCUSSION

Main Findings

The present study is the first report on intelligent healthcare in nursing homes in China. With continuous improvement of life expectancy, many countries in the world are inevitably facing up to the tide of population aging, which can be a burden on society and the national healthcare system. Meanwhile, the demands for healthcare services substantially increased in nursing homes. Providing efficient, high-quality healthcare for older adults can be expensive.² Information and communication technologies are now being proposed to policymakers as an efficient and economical alternative to traditional health services to solve the healthcare issues of older adults, especially those with chronic diseases.¹⁵ With the advent of smart technology solutions, a global society could provide better care to older adults, especially senior citizens.¹⁹ Therefore, exploring the intelligent healthcare measures taken in China could help in formulating recommendations to solve similar problems caused by an aging population in other countries.

In the present study, the majority of the nursing homes provided intelligent healthcare for older adults, especially focused on medical care services and daily life services. Intelligent medical care services included chronic disease management and nursing, while intelligent life services included fall monitoring and wireless positioning. Both types of services

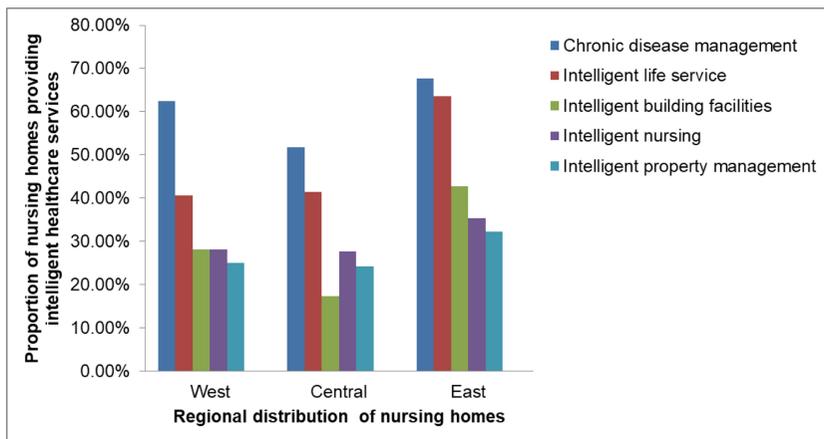


FIGURE 1. Provision of intelligent healthcare services in nursing homes in different regions of China (N = 157).

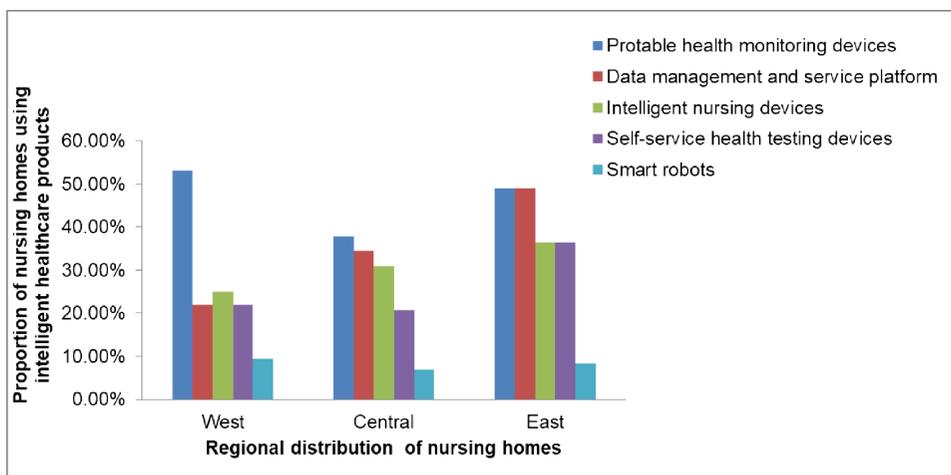


FIGURE 2. Application of intelligent healthcare products in nursing homes in different regions of China (N = 157).

embody the primary healthcare needs of the older adults, which should be given utmost priority.

Neyens et al²⁰ reported that the most prominent cost associated with older adults' health includes those associated with falls and chronic diseases. A combination of clinical recommendations and the involvement of physicians with intelligent health monitoring systems for the elderly can improve patient safety.²¹ A chronic disease care system could improve treatment continuity for adults with type 2 diabetes mellitus.¹³ Additionally, Gokalp and Clarke²² found that most of the existing monitoring systems could provide smart life services such as meal preparation, personal hygiene, bathing, and dressing. These technologies play a pivotal role in improving older adults' daily lives. Previous literature confirmed the advantages of home telemonitoring over usual care in reducing older adults' hospitalization and emergency department visits.²³

Portable health monitoring devices and data management and service platform were the most used healthcare products. Intelligent healthcare products are diverse: they include not only smart wearable devices like smart bracelets and watches but also body implants like epidermal, tissue-embedded, and ingestible sensor devices.²⁴ Moreover, smart technologies, such as tailored Internet programs, may help older adults better manage and understand various health conditions.²⁵ It was worth noting that high-end, technologically advanced smart healthcare products like robots, smart mattresses, intelligent monitoring beds, and smart wheelchairs are less frequently used in nursing homes in China. This may be a result of restricted factors such as limited financial support and a dearth of personnel with proficiency in intelligent technology, as reported by the nursing homes. Other countries may also face similar problems.

We found that the attitudes of stakeholders (staff and residents) play pivotal roles in the provision of intelligent healthcare services. They produce a rich and complex set of "wishes" that

are sufficient to influence the decisions concerning the provision of intelligent healthcare by the nursing home. Positive attitudes of the staff encouraged the nursing homes to provide intelligent healthcare services. Higher financial investment, positive attitudes of the staff, and residents' receptiveness to intelligent healthcare services are associated with greater effectiveness of the application of intelligent healthcare products.

Previous literature also showed that stakeholders played important roles in the application of intelligent healthcare services. Bedaf et al²⁶ found that in a study of the application of assistive service robots in family healthcare for older people, different stakeholders, like older adults and caregivers, held different views. Older people were more positive about its application, but caregivers were more skeptical about technical issues. A qualitative study on mobile information software services application showed that collaboration at the organizational level was needed for operational effectiveness and effective management, which includes support from executives and individuals with technical knowledge.²⁷ The positions of different stakeholders, including older adults, care professionals, managers, technology designers, and suppliers, were influential in the implementation of technology for aging people. Insight into the convergent and divergent perspectives of stakeholders involved in this process could eventually support the successful implementation of aging technologies. Stakeholders need to engage in an ongoing mutual commitment focused on the goal of provision of healthcare services.²⁸ The acceptance of technology is influenced by many factors related to stakeholders, such as concerns regarding technology, expected benefits of technology, need for technology, alternatives to technology, social influence, and the characteristics of older adults.²⁹

LIMITATIONS

This study had some limitations. First, we mainly discussed the opinions and viewpoints of service providers on intelligent

Smart Healthcare Products	Intelligent Healthcare Services
<p>Portable Health Monitoring Devices</p> <p>Portable sphygmomanometer</p> <p>Pulse oximeter</p> <p>Wrist blood glucose tester</p> <p>Dynamic electrocardiogram</p> <p>Mobile terminal</p> <p>Uric acid tester</p> <p>Chest-strap-type heartbeat monitor</p> <p>Data Management and Service Platform</p> <p>Third-party development management platform</p> <p>Mobile terminal</p> <p>Community health service center platform</p> <p>Independent research and development platform</p> <p>Intelligent Nursing Devices</p> <p>Smart mattress</p> <p>Intelligent monitoring bed</p> <p>Smart wheelchair</p> <p>Self-service Health Testing Devices</p> <p>Intelligent check-up kiosk</p> <p>Bone density detector</p> <p>Height and weight</p> <p>Body fat scale</p>	<p>Medical Care Services</p> <p>Chronic disease management</p> <p>Health record management</p> <p>Condition monitoring</p> <p>Personalized health evaluation</p> <p>Medical advice</p> <p>Emergency assistance</p> <p>Abnormal warning</p> <p>Disease trend</p> <p>Internet health advisory service</p> <p>Medical online consultation</p> <p>Pre-diagnosis guidance</p> <p>Follow-up after diagnosis</p> <p>Appointment registration</p> <p>Remote consultation</p> <p>Life Care Services</p> <p>Family care</p> <p>Eating habits</p> <p>Hobbies</p> <p>Fall monitoring</p> <p>Wireless positioning</p>

FIGURE 3. List of the most prevalent intelligent healthcare products and intelligent healthcare services in Chinese nursing homes (N = 157).

healthcare to determine the current situation in nursing homes. We did not survey the working staff that provides healthcare services and the older people who are served. Thus, this study may not accurately represent their thoughts and level of satisfaction with the intelligent healthcare services. Second, the level of development of intelligent healthcare and

the effectiveness of application of intelligent healthcare products were self-evaluated by the administrators of the nursing homes, instead of a systematic objective evaluation index, which may cause some bias. Third, our study did not accurately investigate the health status of the residents in nursing institutions, and we did not quantitatively discuss the benefits

Table 3. Univariate Analysis of the Influential Factors of IH Development and Products Application Effectiveness in Chinese Nursing Homes (N = 157)

Characteristics	Development of IH		P Value	Products Application Effectiveness		P Value
	Bad	Good		Bad	Good	
Financial investment in IH						
Low ($\leq 10\%$)	53 (48.19%)	24 (51.06%)	.014	57 (55.34%)	20 (42.55%)	<.001
Middle (10%–30%)	46 (41.81%)	11 (23.40%)		39 (37.86%)	18 (38.30%)	
High ($> 30\%$)	11 (10%)	12 (25.54%)		7 (6.80%)	16 (34.04%)	
Attitudes of staff to IH						
Disagree	69 (62.7%)	17 (31.2%)	.002	67 (65%)	19 (35.2%)	<.001
Agree	41 (37.3%)	30 (63.8%)		36 (35%)	35 (64.8%)	
Proportion of residents favoring IH						
Low ($< 50\%$)	NA	NA	NS	70 (67.96%)	21 (38.89%)	<.001
High ($\geq 50\%$)	NA	NA		33 (32.04%)	33 (61.11%)	

Abbreviations: IH, intelligent healthcare; NA, not applicable; NS, not significant.

Regional distribution, occupancy rate, number of beds, types of residents served, types of nursing homes were all included in the univariate analysis. Non-significant results are not shown here.

of intelligent healthcare services in improving the service quality and management effectiveness in nursing homes. The cost-benefit analysis of intelligent care service in nursing homes also needs to be further studied.

CONCLUSION

As a developing country with the largest elderly population in the world, China is trying to improve healthcare for older adults by implementing intelligent healthcare. This study revealed the current situation, characteristics, and influencing factors of intelligent healthcare in China. The results showed that nursing homes in China have carried out intelligent healthcare in response to national policies, and different stakeholders play pivotal roles in the provision of intelligent healthcare services. This study holds valuable implications for the policymakers or management personnel of nursing homes both in China and other countries. To improve intelligent healthcare services in nursing homes, the following measures must be considered. First, the government should strengthen the support of intelligent healthcare services by guiding social capital toward the development of a smart healthcare industry. They must work toward creating support with government funds and further actively work toward the purchase of smart healthcare services, thus gradually expanding the purchase of services and improving the content of services. Further, the government should take measures to support the industry of intelligent healthcare, to enrich diversity, enforce operability and innovation, and decrease prices. Second, nursing homes should focus on, and actively respond to, national policy documents and pursue the understanding of the needs of older adults strengthen health education for older adults, enhance older adult

knowledge of intelligent healthcare services, and equip older adults with skills needed for the application of intelligent healthcare products. Additionally, nursing homes should actively conduct educational and training programs on intelligent health services to increase the awareness and the abilities of their staff and further strengthen the understanding of intelligent healthcare services in general.

Table 4. Binary Logistic Analysis of the Influential Factors on the Development of IH and Products Application Effectiveness in Chinese Nursing Homes (N = 157)

Characteristics	OR (95% CI)	P Value
<i>Development of IH</i>		
Attitudes of staff to IH		
Disagree	1 (reference)	.003
Agree	2.97 (1.461–6.038)	
<i>Products application effectiveness</i>		
Attitudes of staff to IH		
Disagree	1 (reference)	<.001
Agree	3.428 (1.72–6.835)	
Financial investment in IH		
Low ($\leq 10\%$)	1 (reference)	.021
Middle (10%–30%)	1.315 (0.618–2.801)	
High ($> 30\%$)	6.514 (2.310–18.136)	
Proportion of residents favoring IH		
Low ($< 50\%$)	1 (reference)	.001
High ($\geq 50\%$)	3.333 (1.679–6.619)	

Abbreviations: IH, intelligent healthcare; OR, odds ratio.

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