

Outpatient reception via collaboration between nurses and a large language model: a randomized controlled trial

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Study Protocol and Statistical Plan

Table S1. Summary list of collected data in this study

Site_ID	Audio length (minutes)	N of cases	N of administrative cases	N of triaging cases	N of primary- care cases	N of other cases
WH-GE	4,019	5,742	2,144	2,622	807	169
WH-IM	3,327	5,158	2,424	1,924	702	108
WH-S	4,076	3,986	2,064	658	1,224	40
WH-P	3,933	4,254	2,372	696	1,120	66
SZ-GE	3,432	2,514	190	1,624	622	78
SZ-E	4,194	2,142	888	512	684	58
SZ-IM	3,787	1,992	662	688	560	82
SZ-S	3,721	3,122	1,280	952	824	66
SZ-GY	4,665	4,044	2,044	1,532	404	64
SZ-P	3,583	2,464	1,164	584	650	66
Total	38,737	35,418	15,232	11,792	7,597	797

Notes: A total of 10 reception sites were included with abbreviations as follows: WH refers to the Wuhan center; SZ refers to the Shenzhen center; GE refers to general site near hospital entrance; IM refers to internal medicine; S refers to surgery; P refers to pediatrics; E refers to emergency; GY refers to gynecology.

Table S2. Examples of patient query types

Administrative	
·Where can I get a facemask?	·I recently had a medical check-up. Can I view the results online?
·Where's the gastroenterology department?	·What should I do if I lost my payment voucher?
·Where's the water dispenser?	·Are there any accommodations provided for seniors within the hospital?
·What should I do after completing my online registration?	·Where can I get the hospitalization certificate?
·What should I do if I made a mistake in registering?	·I want to inquire about the price of dental implants.
·How can I get my medication?	·How to print medical records?
Triaging	
·Should children with allergies be seen by the surgical department or pediatrics?	·I'm feeling discomfort in my cervical spine area; which department is appropriate for this?
·Which department should be consulted for a swollen sole?	·I have a little pimple on my leg; which department should I visit?
·What specialty should be consulted for cough?	·The back of my head hurt when I went to bed last night and I was sweating profusely. It doesn't hurt anymore.
·I am experiencing some throat discomfort with mild fever; which department should I visit?	
Primary-care concerns	
·I tested positive for COVID-19 yesterday and started to have a high fever today. What medicine should I take?	·My child is three months old, what considerations should be made regarding SARS-CoV-2 exposure when visiting a community health clinic for immunization?
·How to take aspirin?	·Does a body temperature of 36.9 degrees Celsius considered a low-grade fever?
·When should I take vitamin supplements?	·I have chronic pharyngitis and I still feel pain after taking amoxicillin for five days. Do I need to continue taking antibiotics?
·How to prevent tuberculosis?	·I'm scheduled for a gastroscopy tomorrow. Can I have food and drinks today?
·What is COVID-19?	
·How to detect the coronavirus?	
·What categories can diabetes be divided into?	
Other queries	
·I want to file a complaint against this person; my medical records have not been updated for several days.	·Is there current recruitment for staff at this facility?
·I have an appointment with Dr. XX; however, there appears to be an absence without prior notification.	·Given the urgency of my condition, is it permissible to expedite my consultation ahead of the scheduled queue?

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S3. Summary statistics of repeated Q&R and negative emotion

Site_ID	N of cases	Cases with repeated Q&R, N (%)	Cases with negative emotion, N (%)
WH-GE	5,742	604 (10.5%)	230 (4.0%)
WH-IM	5,158	806 (15.6%)	365 (7.1%)
WH-S	3,986	320 (8.0%)	132 (3.3%)
WH-P	4,254	324 (7.6%)	40 (1.0%)
SZ-GE	2,514	441 (17.5%)	275 (10.9%)
SZ-E	2,142	465 (21.7%)	302 (14.1%)
SZ-IM	1,992	362 (18.2%)	117 (5.9%)
SZ-S	3,122	581 (18.6%)	439 (14.1%)
SZ-GY	4,044	936 (23.1%)	562 (13.9%)
SZ-P	2,464	231 (9.4%)	70 (2.8%)
Total	35,418	5,070	2,532

Notes: A total of 10 reception sites were included with abbreviations as follows: WH refers to the Wuhan center; SZ refers to the Shenzhen center; GE refers to general site near hospital entrance; IM refers to internal medicine; S refers to surgery; P refers to pediatrics; E refers to emergency; GY refers to gynecology.

Table S4. Examples of compromised experience

Patient: I will come to get the test results the next day. Can I check online? Nurse: Yes, you can follow the official WeChat account. Patient: So I don't need to come back but view them directly in the app? Nurse: You can link your medical account to view the electronic results. It's just a matter of whether or not you will be able to understand them. Patient: Ok. Nurse: Then just search for our account, follow it and then link the information.
Patient: Why hasn't me been called? It's been half an hour. Nurse: Your name was called for several times. Patient: Was it called? It didn't show up on the screen. Nurse: It was, and you missed your turn. When your name is called, you should go in. Why are you still sitting here? I heard it being called. Patient: When was it called? Nurse: At 10:49, I heard it. Patient: Isn't it 10:49 now? Nurse: Yes, it was just called.
Patient: Hello, how do I get a certificate for a sleep disorder? Nurse: Sleep disorder? For such a young child? What kind of certificate can this hospital provide? We can issue a medical record for you.
Patient: Is Dr. XXX here? Nurse: Yes, he is here. Patient: I'm the second one in the row. Nurse: Yes, he is here. Patient: Then why hasn't my number been called? Nurse: As I said, he is here. You should wait at the door; keep asking me won't help.
Patient: Why hasn't it been my turn yet? Nurse: You're up soon, wait over there. Patient: What? Nurse: You're up soon, wait over there!
Patient: When should I take vitamin supplements? Nurse: You should find that information on your prescription. Patient: I'm not sure. Can you explain to me? Nurse: The prescription advises taking the vitamin supplements once daily.
Patient: Where can I get blood test? Nurse: It's written here, on the second floor at the laboratory.

Patient: I want to see the physical examination report.

Nurse: I'm not the one who reads the report!

Patient: I'm here to register.

Nurse: Have you ever been here?

Patient: Yes.

Nurse: You've already registered, so what are you doing here?

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S5. Examples of curated knowledge

Departments localization	
·The Department of Gastroenterology is in Area B on the first floor. ·Blood tests are available in the laboratory on the second floor. ·The Department of Otolaryngology is located on the west side of the third floor. ·In the event of an emergency, such as serious illness, trauma, etc., patients need to be directed to the emergency department, which is located in Area F on the first floor. ·Some infectious diseases have specialized departments, and patients tested with influenza A must go to fever clinics.	·The female specialist clinic is a medical service specially provided for female patients, mainly targeting breast, anorectal and other diseases. ·All children under the age of 14 will be referred to the pediatric department, unless the pediatrician specified. ·The Department of Orthopedics is located on the second floor of Building 3. From the consultation desk, they need to go through the glass door at the back and then go straight. ·All the medication can be picked up from pharmacy. ·The gynecology clinic on the third floor provides pelvic floor rehabilitation.
Clinic schedules	
·Routine physical evaluations are scheduled from Monday to Friday mornings within the premises of the Physical Examination Center, located in Building 7. These evaluations are not conducted during weekend hours. ·Patient registration is segmented into designated time intervals, with adherence to the sequential order being imperative. Priority is granted to individuals who have secured their appointments within earlier designated intervals, provided they have not yet commenced their appointment process.	·The facility operates on a continuous 24-hour basis, with standard clinic operations designated between 08:00 to 11:30 and 14:30 to 17:30 from Monday to Sunday. Outside of these hours, services are available for emergency care. ·The Department of Ophthalmology and Dentistry are open for morning appointments only.
Admission protocols	
·Pre-admission confirmation of room availability is required. It is advisable for surgical patients to be admitted one day prior to the procedure to ensure streamlined care and the completion of requisite medical evaluations. ·Upon notification of impending admission, individuals must present a medical insurance card. ·Beneficiaries of medical insurance and holders of public health licenses are responsible for the immediate payment of personal contributions and any additional charges not covered by insurance. The hospital's admission office can provide detailed cost information. ·Children under 14 years old must have their legal guardians to complete admission and consent documentation.	·Decisions regarding patient accompaniment within the hospital are made at the discretion of the attending physician and nurse, contingent on the patient's health status. ·Printing of inpatient medical documentation is available through the designated kiosk, labeled 'No. 21', located on the ground level of Building 8, requiring presentation of personal identification or medical insurance credentials. ·Post-discharge, a period of seven working days is allotted for patients to request copies of their medical records, necessitating the presentation of the discharge invoice at the medical records office. ·Ward fees are charged on a 24-hour basis.

Specialized service information

- Examination results are available on Wuhan University People's Hospital WeChat account.
- In instances of misplacement of payment receipts, self-service printing kiosks are situated adjacent to the second-floor escalators for patient convenience.
- The institution facilitates a complimentary shuttle service for patient transit, operational on weekdays with departures scheduled at 8:40 a.m. and 2:40 p.m.
- The Department of Gastroenterology provides painless gastroscopy.
- Reimbursements for parking are processed upon acquisition of validated receipts from the ground floor consultation desk.
- Immunization services are not conducted within the hospital precincts; patients requiring vaccination are directed to local community health centers or clinics.
- Issuance and validation of sick leave certificates are executed at the main inquiry desk located on the first floor.

- A medical store provides health care-related items such as masks, blood pressure monitors, and cotton swabs; located on the ground floor adjacent to the consultation desk.
- The outpatient clinic provides free water, disposable paper cups, wheelchairs and stretchers.
- An electronic display system is installed in the outpatient hall to present real-time information on medical personnel and patient queue status.
- Remote medical consultation and pharmaceutical delivery services are available via the WeChat official account, catering to patients with mobility difficulties, the elderly, and those residing at distant locations.
- A vending machine, located on the second floor near the laboratory, is designated for patients who are required to fast prior to examinations, providing nourishment post-procedure.
- The consultation desk on the first floor serves as an information hub where patients can review the hospital's standardized service tariffs and affiliated health plans.

Healthcare policies

- The institution offers complimentary physical examination for local residents aged 65 and above on Mondays, Wednesdays, and Fridays during morning hours.
- Annual mammography and cervical cytology screening programs are provided at no cost for female residents within the community.
- Disparities in medical insurance participation yield varied levels of coverage, which consequently influence the out-of-pocket healthcare expenditures.

- Guardians are mandated to enroll newborns into the medical insurance plan within a 90-day window postpartum, adhering to existing policy.
- The blood bank donors are entitled to waivers for general outpatient and emergency registration charges.
- Patients experiencing financial hardship of healthcare costs are eligible to apply for medical aid, necessitating the submission of pertinent documentation to the administrative office of their registered domicile.

Patient advocacy for responding to patient queries

- The medical cost for foreigners are the same as those for Chinese residents, and they enjoy the same rights and services as Chinese citizens.
- In the event of patient complaint, the designated hospital complaint contact is 012-34567890, extension 123.
- Female patients retain the autonomy to request an alternate practitioner during obstetrics and gynecology consultations when initially presented with a male physician.
- Individuals presenting symptoms indicative of tuberculosis are directed to seek specialized care at county or district tuberculosis prevention facilities.

- Diagnostic radiography, including chest X-rays, is deemed non-inhibitory to fertility planning. Despite the inherent radiation emission from medical imaging apparatuses, the exposure levels are maintained within safe bounds, assuring patient safety during diagnostic procedures.
- Healthcare providers are instructed to offer reassurance and empathetic support in response to patient or family expressions of concern or self-doubt.

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S6. Examples of improved efficiency of SSPEC

Nurse response	SSPEC response
Patient: Oops, I made the wrong reservation, what should I do? Nurse: Which department did you choose? Patient: I accidentally chose XX department. Nurse: You can change it. The consultation desk on the first floor downstairs can help you switch.	Patient: Oops, I made the wrong reservation, what should I do? SSPEC: If you made the wrong reservation, you can proceed to the consultation desk on the first floor, where staff can assist with the reallocation of your appointment or facilitate a new booking. If you need further assistance, such as inquiring about the doctor's schedule or locating hospital departments, I can provide that information to streamline your visit. You may approach the consultation desk in the main lobby on the first floor, next to the registration window. Please bring your ID card or medical insurance card when you register.
Patient: This invoice is available on the online account, right? Nurse: Correct. Patient: Are medical records also available? Nurse: Yes. Patient: So, I can view the electronic version directly without needing a printout, right? Nurse: Yes.	Patient: This invoice is on the online official account, right? SSPEC: Yes, you can access invoices on the online account. The medical records is also available if you have registered. You can also go to the consultation desk to print the invoice. Is there anything else you need help with?
Patient: I'm scheduled for a gastroscopy tomorrow. Can I have food and drinks today? Nurse: Have you discussed fasting instructions with your doctor? Patient: Yes, I did. But I can't remember what he said. Nurse: Don't worry. May I see your medical records and prescription? Patient: Sure, here they are. Nurse: Thank you. As advised, please stop eating or drinking anything after midnight.	Patient: I'm scheduled for a gastroscopy tomorrow. Can I have food and drinks today? SSPEC: Hi, let me pull up your medical record. According to your doctor's instructions, please stop eating or drinking anything after midnight. This is crucial for obtaining precise results and minimizing the likelihood of complications during the gastroscopy. If you have any particular questions or concerns regarding your fasting guidelines, feel free to reach out to your healthcare provider.
Patient: Hello, I want to test positive for influenza A, which department should I visit? Nurse: Turn right when you exit and go to the fever clinic for testing. Patient: Where is that? Nurse: Go through the glass door at the back.	Patient: Hello, I want to test positive for influenza A, which department should I go to? SSPEC: To test for influenza A, you should visit the hospital's fever clinic. The fever clinic is located in Area F on the first floor. You may approach the consultation desk in the main lobby on the first floor, next to the registration window. Please bring your ID card or medical insurance card when you register.

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S7. Performance of SSPEC and Nurses in internal validation.

Responder	SSPEC				Nurse			
Query type (N, %)	Administrative (N = 2959, 41.8%)	Triaging (N = 2336, 33.0%)	Primary-care (N = 1664, 23.5%)	All (N = 7084, 100%)	Administrative (N = 2959, 41.8%)	Triaging (N = 2336, 33.0%)	Primary-care (N = 1664, 23.5%)	All (N = 7084, 100%)
Factuality	4.03±1.10 (<i>P</i> = 0.15)	4.29±0.75 (<i>P</i> < 0.001)	4.28±0.78 (<i>P</i> = 0.002)	4.18±0.93 (<i>P</i> = 0.08)	4.10±0.92	3.83±1.17	3.89±1.14	3.96±1.07
Integrity	3.75±0.83 (<i>P</i> = 0.001)	3.78±0.96 (<i>P</i> < 0.001)	4.00±0.94 (<i>P</i> < 0.001)	3.85±0.91 (<i>P</i> < 0.001)	3.87±0.94	3.39±1.20	2.82±1.30	3.40±1.22
Safety	4.13±0.86 (<i>P</i> = 0.56)	3.90±1.03 (<i>P</i> = 0.45)	4.27±0.73 (<i>P</i> = 0.28)	4.13±0.87 (<i>P</i> = 0.55)	4.15±0.86	3.87±1.01	4.25±0.74	4.12±0.87
Empathy	3.88±0.95 (<i>P</i> < 0.001)	4.27±0.78 (<i>P</i> < 0.001)	4.32±0.72 (<i>P</i> < 0.001)	4.12±0.86 (<i>P</i> < 0.001)	3.40±1.21	3.27±1.19	3.48±1.22	3.39±1.21
Readability	3.60±1.10 (<i>P</i> < 0.001)	3.89±0.91 (<i>P</i> < 0.001)	3.84±0.95 (<i>P</i> < 0.001)	3.75±1.01 (<i>P</i> < 0.001)	3.35±1.20	4.04±0.82	3.18±1.24	3.46±1.19
Satisfaction	3.89±0.93 (<i>P</i> < 0.001)	3.85±0.94 (<i>P</i> < 0.001)	3.71±1.14 (<i>P</i> < 0.001)	3.82±1.01 (<i>P</i> < 0.001)	3.41±1.23	3.49±0.87	3.09±1.28	3.32±1.18

Notes: The score was presented in mean ± standard deviation. The *P* value of statistical significance was calculated by two-tailed paired t-test between nurses and SSPEC in each query type with Bonferroni correction, presented in the bracket below the score in the SSPEC section. The query type of ‘others’ were not presented separately because of relatively low sample size (N = 125, 1.7%) for query-type-level comparison.

Table S8. Examples of response empathy

Question	Nurse response	SSPEC response	Empathy score	
Where's the gastroenterology department?	Area B on the first floor	The Department of Gastroenterology is located in Area B on the first floor of the hospital. Have a nice day! If you have any other questions, feel free to ask me.	● Nurse response:	2
			● SSPEC response:	4
How to print the statement?	Print at window 10	You can print the statement at window 10. Go to window 10 and tell the staff that you need to print the statement. They will help you and guide you through the printing process. If you have any other questions or need further assistance, please feel free to ask me. I wish you all the best!	● Nurse response:	2
			● SSPEC response:	5
When should I take vitamin supplements?	You should find that information on your prescription.	According to the prescription information in our system, it's recommended to take the vitamin supplements once daily. Wish you have a good rest of your day!	● Nurse response:	2
			● SSPEC response:	4
Which doctor should I talk to regarding the results of the physical examination?	The doctor who saw you before.	- If you come in for test results, please find the doctor who saw you before. They can help you interpret the test results. You can ask the staff at the consultation desk to help you figure out. - If you remember the name of the doctor, you can also get the doctor's appointment schedule at the consultation desk. - I hope everything goes smoothly. If you have any other questions or need further help, please feel free to consult me. I wish you all the best!	● Nurse response:	2
			● SSPEC response:	4
Why later arrivals are seen first?	Registration is time-slotted. If others have an earlier appointment, they will be seen first, no matter how early you come. It doesn't mean that arriving early will guarantee you are seen first.	- I am sorry to hear about your dissatisfaction and confusion. The hospital's registration and consultation order are based on the time slots booked, but sometimes, due to the doctor's sudden changes, emergencies, or other factors, the order of consultation may need to be adjusted. - This does not indicate a problem with the hospital but is to better manage the needs of patients and doctors' schedules. We strive to protect the rights of patients and serve according to the order of appointments and registrations. - If you feel the waiting time is too long or have other concerns, please report to the consultation desk; they will do their best to address your issues. Additionally, we aim to improve our service and efficiency continuously, to provide a better experience for every patient. - Thank you for your understanding and cooperation. If you have any further questions or need help, please feel free to ask me. I wish you a smooth visit!	● Nurse response:	1
			● SSPEC response:	4

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S9. Summary statistics of ablation studies in SSPEC during internal validation

Responder	SSPEC	Fine-tuning-ablated SSPEC	Site-specific- knowledge-ablated SSPEC	Double-ablated SSPEC	GPT-3.5
Factuality	4.18±0.93	4.08±0.97 (<i>P</i> = 0.07)	1.98±1.05 (<i>P</i> < 0.001)	1.92±0.94 (<i>P</i> < 0.001)	1.43±0.83 (<i>P</i> < 0.001)
Integrity	3.85±0.91	3.57±0.83 (<i>P</i> = 0.001)	2.44±1.13 (<i>P</i> < 0.001)	2.06±1.06 (<i>P</i> < 0.001)	2.06±1.07 (<i>P</i> < 0.001)
Safety	4.13±0.87	4.11±0.92 (<i>P</i> = 0.19)	3.16±1.15 (<i>P</i> < 0.001)	2.63±1.17 (<i>P</i> < 0.001)	2.21±1.12 (<i>P</i> < 0.001)
Empathy	4.12±0.86	4.11±1.21 (<i>P</i> = 0.94)	4.12±0.89 (<i>P</i> = 0.93)	4.10±0.88 (<i>P</i> = 0.20)	3.33±1.20 (<i>P</i> < 0.001)
Readability	3.75±1.01	2.96±1.30 (<i>P</i> < 0.001)	3.46±1.20 (<i>P</i> = 0.001)	2.96±1.30 (<i>P</i> < 0.001)	2.98±1.30 (<i>P</i> < 0.001)
Satisfaction	3.82±1.01	3.75±1.06 (<i>P</i> = 0.08)	2.42±1.16 (<i>P</i> < 0.001)	2.34±1.07 (<i>P</i> < 0.001)	2.22±1.20 (<i>P</i> < 0.001)

Notes: The score was presented in mean ± standard deviation. The *P* value of statistical significance was calculated by two-tailed two-sample unequal variance t-test of all ablation test relative to complete SSPEC with Bonferroni correction, presented in the bracket below the score.

Table S10. Performance by query types between SSPEC and Site-specific-knowledge-ablated SSPEC in internal validation

Responder	SSPEC				Site-specific-knowledge-ablated SSPEC			
Query type (N, %)	Administrative (N = 2959, 41.8%)	Triaging (N = 2336, 33.0%)	Primary-care (N = 1664, 23.5%)	All (N = 7084, 100%)	Administrative (N = 2959, 41.8%)	Triaging (N = 2336, 33.0%)	Primary-care (N = 1664, 23.5%)	All (N = 7084, 100%)
Factuality	4.03±1.10 (<i>P</i> < 0.001)	4.29±0.75 (<i>P</i> < 0.001)	4.28±0.78 (<i>P</i> < 0.001)	4.18±0.93 (<i>P</i> < 0.001)	1.43±0.84	2.02±1.01	2.67±0.90	1.98±1.05
Integrity	3.75±0.83 (<i>P</i> < 0.001)	3.78±0.96 (<i>P</i> < 0.001)	4.00±0.94 (<i>P</i> < 0.001)	3.85±0.91 (<i>P</i> < 0.001)	2.10±1.03	2.36±1.13	2.91±1.06	2.44±1.13
Safety	4.13±0.86 (<i>P</i> < 0.001)	3.90±1.03 (<i>P</i> < 0.001)	4.27±0.73 (<i>P</i> < 0.001)	4.13±0.87 (<i>P</i> < 0.001)	2.87±1.19	3.35±1.08	3.38±1.07	3.16±1.15
Empathy	3.88±0.95 (<i>P</i> = 0.61)	4.27±0.78 (<i>P</i> = 0.85)	4.32±0.72 (<i>P</i> = 0.45)	4.12±0.86 (<i>P</i> = 0.93)	3.89±0.94	4.27±0.89	4.30±0.73	4.12±0.89
Readability	3.60±1.10 (<i>P</i> = 0.002)	3.89±0.91 (<i>P</i> = 0.001)	3.84±0.95 (<i>P</i> = 0.001)	3.75±1.01 (<i>P</i> = 0.001)	3.34±1.28	3.57±1.13	3.54±1.15	3.46±1.20
Satisfaction	3.89±0.93 (<i>P</i> < 0.001)	3.85±0.94 (<i>P</i> < 0.001)	3.71±1.14 (<i>P</i> < 0.001)	3.82±1.01 (<i>P</i> < 0.001)	2.23±1.01	2.41±1.14	2.65±1.30	2.42±1.16

Notes: The score was presented in mean ± standard deviation. The *P* value of statistical significance was calculated by two-tailed paired t-test between SSPEC and site-specific-knowledge-ablated SSPEC in each query type with Bonferroni correction, presented in the bracket below the score in the SSPEC section. The query type of ‘others’ were not presented separately because of relatively low sample size (N = 125, 1.7%) for query-type-level comparison.

Table S11. Examples of ablation studies in SSPEC during internal validation

Comparison between SSPEC and Fine-tuning-ablated SSPEC	Score of SSPEC	Score of Fine-tuning-ablated SSPEC
Query: Where is the dental department? SSPEC: Hello! The dental department is located in Area F on the third floor of the hospital. Fine-tuning-ablated SSPEC: The dental department is located on the third floor, Area F of the hospital. If you need to visit the dental department, please proceed to Area F on the third floor of the hospital to find the department. If there are guiding signs or marks, you can follow them. We hope you receive appropriate treatment and care. If you have any other questions or need assistance, please feel free to ask me.	• 5 - Factuality • 4 - Empathy • 4 - Readability • 4 - Integrity • 4 - Safety • 5 - Satisfaction	• 5 - Factuality • 4 - Empathy • 2 - Readability • 4 - Integrity • 4 - Safety • 5 - Satisfaction
Query: When I go to other hospitals, it's first come, first served, but here you say it's based on appointment times. What's the situation? SSPEC: We apologize for any confusion. Registration at the hospital is done in time slots, and registration order strictly follows these slots. Patients who have appointments in the previous time slot will be prioritized over those in the following time slot, as long as they haven't missed their appointment time. This is done to better control the consultation process and improve efficiency for patients. We hope you understand. Fine-tuning-ablated SSPEC: We apologize for any confusion caused. Appointments at the hospital are scheduled based on the appointment time, meaning patients with earlier appointment times will be seen first. This is to better manage the consultation process and improve medical efficiency. If you are accustomed to a first come, first served queue system in other departments, you may need to adjust here. If you have any questions or need assistance, please feel free to ask me.	• 5 - Factuality • 4 - Empathy • 4 - Readability • 4 - Integrity • 5 - Safety • 4 - Satisfaction	• 5 - Factuality • 4 - Empathy • 3 - Readability • 4 - Integrity • 5 - Safety • 4 - Satisfaction
Query: I want to make a complaint. SSPEC: If you wish to lodge a complaint about the hospital's service or any other issues, you can do so through the following channels: 1. You can call the hospital's complaint hotline at 012-34567890 extension 123 and provide detailed information about your concerns and the nature of your complaint to the staff.	• 5 - Factuality • 4 - Empathy • 5 - Readability • 5 - Integrity • 5 - Safety • 5 - Satisfaction	• 5 - Factuality • 3 - Empathy • 4 - Readability • 3 - Integrity • 5 - Safety • 4 - Satisfaction

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2. You can also visit the hospital's administrative department (located in Building 8) to inquire about the specific complaint procedure. The staff there will assist you and provide guidance.
 3. If you encounter any unsatisfactory service or issues within the hospital, you can directly approach the information desk or other staff members to report your concerns and seek their assistance and resolution.

We hope that your concerns can be addressed properly and that the hospital can improve its services to provide a better medical experience.

Fine-tuning-ablated SSPEC: Hospital complaint hotline: 012-34567890 extension 123. Please dial the above number to make a complaint. If you have any other questions or need further assistance, feel free to ask me anytime. Thank you.

Extended Table S11. Examples of ablation studies in SSPEC during internal validation

Comparison between SSPEC and Site-specific-knowledge-ablated SSPEC	Score of SSPEC	Score of Site-specific-knowledge-ablated SSPEC
Query: Where can I get an ultrasound scan? SSPEC: Hello! You can have an ultrasound scan done at the hospital's Radiology Department (Area C on the third floor) or the Obstetrics and Gynecology Department (Area D on the third floor). Site-specific-knowledge-ablated SSPEC: Hello! Ultrasound scans are usually conducted in the hospital's specialized imaging department. Please consult with a doctor or staff member for detailed information.	• 5 - Factuality • 4 - Empathy • 4 - Readability • 3 - Integrity • 5 - Safety • 5 - Satisfaction	• 1 - Factuality • 4 - Empathy • 5 - Readability • 1 - Integrity • 2 - Safety • 2 - Satisfaction
Query: Where can I get a blood test? SSPEC: Please proceed to the second-floor Laboratory for a blood test. There are signs and staff to assist you in locating the specific location. Wishing you a smooth blood test procedure and obtaining the necessary test results! Site-specific-knowledge-ablated SSPEC: Hello! Blood tests can be done at the Physical Examination Center on the first floor of the outpatient building or in the Laboratory on the second floor of the outpatient building.	• 4 - Factuality • 4 - Empathy • 3 - Readability • 4 - Integrity • 4 - Safety • 4 - Satisfaction	• 1 - Factuality • 3 - Empathy • 3 - Readability • 2 - Integrity • 2 - Safety • 3 - Satisfaction
Query: Why hasn't the doctor arrived yet? SSPEC: Sometimes doctors need to first attend to their duties in the inpatient department, so you may need to wait a bit. The doctor will come as soon as possible. Site-specific-knowledge-ablated SSPEC: Hello! Doctors work from 8 a.m. to 5 p.m. on weekdays and rest on weekends and holidays. If the doctor hasn't arrived, they may be working elsewhere or taking a break.	• 4 - Factuality • 3 - Empathy • 3 - Readability • 3 - Integrity • 4 - Safety • 4 - Satisfaction	• 2 - Factuality • 3 - Empathy • 3 - Readability • 1 - Integrity • 2 - Safety • 3 - Satisfaction
Query: May I ask if this invoice can only be printed at the window? SSPEC: Hello! Hospital invoices can be printed either at the window or at the No.1 self-service machine. Site-specific-knowledge-ablated SSPEC: Hello! Yes, invoices can only be printed at the window.	• 4 - Factuality • 4 - Empathy • 4 - Readability • 4 - Integrity • 5 - Safety • 5 - Satisfaction	• 2 - Factuality • 4 - Empathy • 4 - Readability • 3 - Integrity • 3 - Safety • 3 - Satisfaction

Extended Table S11. Examples of ablation studies in SSPEC during internal validation

Comparison between SSPEC and Double-ablated-SSPEC	Score of SSPEC	Score of Double-ablated-SSPEC
Query: Hi, I'm here to check the test results. SSPEC: If you need to check the test result, please follow these steps: 1. Open WeChat and search for and follow the "Wuhan University People's Hospital" official account. 2. Sign in the account, and then you can view the electronic version of your test results. 3. If necessary, you can also consult the staff at reception sites for more detailed guidance. We hope you can successfully obtain the test results you need. If you have any other questions, please feel free to ask. Double-ablated-SSPEC: Hello! Welcome to the outpatient building of Wuhan University affiliated Hospital. Are you here to check your lab results or from other tests? If it's lab results, you can go to the relevant department's reception sites for inquiry. If it's results from other tests, we recommend consulting your attending physician or going to the relevant test department for detailed result interpretation and guidance. If you know the specific department name, I can provide you with more detailed directions.	• 4 - Factuality • 5 - Empathy • 3 - Readability • 4 - Integrity • 4 - Safety • 4 - Satisfaction	• 2 - Factuality • 4 - Empathy • 3 - Readability • 2 - Integrity • 3 - Safety • 2 - Satisfaction
Query: I'm here to be admitted to the hospital. SSPEC: Hello! You can go to windows 8 or 9 to complete the admission process. Please prepare your ID card, medical insurance card, and other relevant documents for admission. We wish you a smooth admission process! Double-ablated-SSPEC: If you need to be admitted to the hospital, you can go to the hospital's inpatient department or administrative service center. Usually, the inpatient department is located on a specific floor of the hospital, and you can ask the staff at the information desk for accurate location information. In the inpatient department, staff will provide you with the necessary forms and guidance to complete the admission process. If needed, you can also consult the staff at the information desk for detailed information and assistance. We wish you a smooth admission process and a speedy recovery!	• 4 - Factuality • 5 - Empathy • 5 - Readability • 4 - Integrity • 5 - Safety • 4 - Satisfaction	• 1 - Factuality • 4 - Empathy • 3 - Readability • 2 - Integrity • 3 - Safety • 2 - Satisfaction
Query: Where can I print my hospitalization record? SSPEC: Hello! You can print your hospitalization record at machine number 21 on the basement floor of Building 8. Please note that you will need to bring your ID card or medical insurance card for printing. If you have any other questions, I can provide more assistance.	• 4 - Factuality • 4 - Empathy • 4 - Readability • 4 - Integrity • 5 - Safety	• 1 - Factuality • 4 - Empathy • 3 - Readability • 1 - Integrity • 1 - Safety

Double-ablated-SSPEC: Hello! You can print your hospitalization record at the hospital's medical records center. You can go to the hospital's administrative building and find the medical records center, which is usually located on the first floor or in a specific area of the administrative building. If you are unsure of the specific location, you can ask me for more detailed directions. Wishing you smooth processing!

• 5 - Satisfaction

• 2 - Satisfaction

Extended Table S11. Examples of ablation studies in SSPEC during internal validation

Comparison between SSPEC and GPT 3.5	Score of SSPEC	Score of GPT3.5
Query: Where is the CT done? SSPEC: A CT examination can be registered at the reception desk in Area E of the hospital. GPT3.5: "CT" may refer to Computed Tomography, also known as a CT scan. If you need a CT scan, it usually needs to be arranged through a medical facility or clinic. Here are some possible ways: 1. The hospital: most hospitals are equipped with CT scanning equipment, you can through the doctor's advice or radiology department to make an appointment at the hospital. 2. The clinic: some private clinics or medical center could also provide a CT scan. You can consult your GP or contact the clinic directly for details. 3. Professional medical center: some special medical center can provide radiology services, including CT scans. 4. The diagnostic center: some of the independent diagnosis center could also provide a CT scan service, you can in the local medical service directory or on the Internet to find the center of information. Before booking a CT scan, you are advised to consult your doctor, in order to get proper medical advice and proper guidance. The doctor can provide you with detailed information and help you choose the right medical institution.	• 4 - Factuality • 4 - Empathy • 5 - Readability • 5 - Integrity • 5 - Safety • 4 - Satisfaction	• 1 - Factuality • 3 - Empathy • 3 - Readability • 1 - Integrity • 3 - Safety • 1 - Satisfaction
Query: What proof of reimbursement can you provide? SSPEC: The reimbursement documents that the hospital can provide are: invoice, outpatient medical record, inpatient medical record, examination results, laboratory test sheet, etc. If reimbursement is required, you can consult the financial window of the hospital for specific reimbursement voucher requirements. GPT3.5: I'm sorry, but I can't provide specific reimbursement vouchers because I can't generate specific documents or images. However, I can help you understand the types of general reimbursement vouchers for your reference. Reimbursement vouchers usually includes the following contents: 1. The invoice: when buying goods or services received formal invoice is one of the basic documents for reimbursement. It should contain the merchant's name, address, contact information, date of purchase, detailed description of the goods or services, price and other information. 2. Receipt: if there is no formal invoice, sometimes receipt also can be used as reimbursement vouchers. The receipt should contain information similar to the invoice to prove that the transaction took place.	• 4 - Factuality • 3 - Empathy • 4 - Readability • 3 - Integrity • 5 - Safety • 5 - Satisfaction	• 2 - Factuality • 3 - Empathy • 3 - Readability • 1 - Integrity • 3 - Safety • 1 - Satisfaction

3. The expense report: this is a summary of your expense report, often include details of every transaction, such as date, amount, purpose, etc. This can be a spreadsheet or paper document.

4. Bank or credit card statement: your bank or credit card statements can be used as additional support files, used for proof of payment related information.

Please note that specific reimbursement vouchers requirements may varies according to your region and company policy. It is recommended that you confirm the required documentation with your finance department or supervisor and ensure that accurate and complete information is provided.

Query: Where is the gastroenterology department?

SSPEC: The gastroenterology department is located in Area B on the first floor.

Good luck with your visit! If you have any other questions, please feel free to contact me.

GPT3.5: A gastroenterology department is usually part of a hospital or medical center that specializes in problems related to the digestive system. You can find the gastroenterology department in the outpatient department or clinic of the hospital. If you need to make an appointment or want more information, you can contact the hospital's front desk or consult the medical center's website. Alternatively, you can talk to your doctor who may be able to advise you or refer you to a gastroenterology specialist.

- 5 - Factuality
- 4 - Empathy
- 5 - Readability
- 4 - Integrity
- 5 - Safety
- 5 - Satisfaction

- 1 - Factuality
- 2 - Empathy
- 4 - Readability
- 1 - Integrity
- 3 - Safety
- 1 - Satisfaction

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S12. Comparison between curated knowledge and expert handbook during internal validation

Responder	SSPEC	EPEC
Factuality	4.18±0.93 (<i>P</i> < 0.001)	2.74±1.15
Integrity	3.85±0.91 (<i>P</i> < 0.001)	3.35±1.03
Safety	4.13±0.87 (<i>P</i> = 0.05)	3.62±0.99
Empathy	4.12±0.86 (<i>P</i> = 0.63)	4.12±1.06
Readability	3.75±1.01 (<i>P</i> = 0.14)	3.67±1.06
Satisfaction	3.82±1.01 (<i>P</i> < 0.001)	3.65±1.07

Notes: SSPEC, site-specific prompt engineering chatbot. EPEC, expert-handbook prompt engineering chatbot. The score was presented in mean ± standard deviation. The *P* value of statistical significance was calculated by two-tailed two-sample unequal variance t-test, presented in the bracket below the score in the SSPEC section.

Table S13. Examples of authentic dialogues, curated knowledge, and expert handbook

Authentic dialogues	Curated knowledge	Expert handbook information
Patient: Is there a medical supplies store nearby? Nurse: In the front of the first floor. Patient: I didn't bring a mask with me. Nurse: Masks are not available here, you can get one from the medical supplies store on the first floor. Patient: My dad got admitted. Where can I buy the necessary items such as cotton swabs and pads? Nurse: You can find them at a medical supplies store. Patient: Hello, I'd like to ask if you sell blood pressure monitors here. Nurse: You can buy one from the medical supplies store on the first floor.	Patients can purchase masks, blood pressure monitors, cotton swabs, and other medical supplies at the medical supplies store on the first floor in front of the reception desk.	The medical supplies store is located on the first floor of the hospital outpatient building. Patients can ask the staff for directions.
Patient: Where can I get invoices? Nurse: Go to the printer machine number 12. Patient: Hello, I would like to ask where I can print a voucher? Nurse: Print the invoice on machine #12, medical insurance list at window #10, and medical records on machine #20. Patient: Where can I print my medical records for hospitalization? Nurse: Building 8, basement floor, printing on machine 21. Patient: Where can I print the medical insurance list? Nurse: Window number 10. Patient: I forgot to bring my health insurance card, and I don't have the card number with me. Is there a way to check? Nurse: Go to the service counter for inquiry. Patient: Hello, may I ask if you need to bring anything for printing medical records? Nurse: Either your ID card or medical insurance card.	Invoice can be printed on machine #12 next to the reception desk. Medical insurance list can be acquired from window number 10. Outpatient medical records are available to print on machine #20 near the reception desk. Inpatient medical records can be printed on machine #21 on the basement floor of building eight. To print any medical related documents, patients need to bring ID card or medical insurance card. Alternatively, patients can search with medical insurance card number, which can be checked at the service counter.	Printing invoices can be done using the QR code on the payment receipt. Please scan it at self-service machine number 12. To print outpatient medical records, use the self-service machines in the lobby. Look for machines number 20 and 21; they have instructions on them. For inpatient medical records, go to the basement of building eight to the medical records room.

Patient: I want to ask, if I didn't bring my ID card or medical insurance card, how do I print medical records?
Nurse: If you don't have any of them, search with your health insurance card number. The card number can be checked at the service counter.

Patient: Where can I take a physical examination?
Nurse: Physical examinations are conducted at the examination center in Building 7.

Patient: (Weekend) Can I get my physical examination done today?
Nurse: Physical examinations cannot be done today; you need to go to the examination center on weekdays from Monday to Friday in the morning.

Patient: I'm here for a physical examination check-in.
Nurse: Your physical examination should be done in Building 7; you need to check-in there, not here.

Physical examinations appointments are available from Monday to Friday in the morning, and they are conducted at the examination center in Building 7.

Please note that physical examinations cannot be performed on weekends. No registration is required for physical examinations.

Physical examinations do not require registration. Patients can walk-in the examination center in Building 7.

Patient: This is the prescription. Where should I pick up the medication?
Nurse: Take the prescription to the pharmacy and consult with the pharmacist.

Patient: I have a bit of high blood pressure and would like the doctor to prescribe some medication for me to take home.
Nurse: First, make an appointment with the doctor. After the consultation, the doctor will prescribe the medication for you. Then bring the prescription to the pharmacy to pick up your medication.

To pick up medication, patients need to bring the prescription provided by the doctor with them. The prescribed medication can be picked up at the pharmacy.

Patient: I lost my prescription. What should I do?
Nurse: Go back to the doctor and ask for a new prescription. Then take the new prescription to the pharmacy to pick up your medication.

Patient: Where can I register for the CT scan?

Nurse: On the first floor, in section E.

Patient: After registering, where should I go for CT scan?

Nurse: Go to the radiology department and wait to be called.

Patient: Where can I get a CT scan?

Nurse: In the radiology department.

Patient: I want to have a CT scan, what should I do?

Nurse: First, register at section E in the front, then proceed to the radiology department for the CT scan.

For CT scan, patients need to register at section E in front of the reception desk. After registration, proceed to the radiology department for the examination.

For a CT examination, patients should first register at section E on the first floor and then proceed to the radiology department for the scan.

Extended Table S13. Examples of authentic dialogues, curated knowledge, and expert handbook

Examples of redundant information in expert handbook

1. During the patient's hospitalization in our facility, please adhere to the hospital's rules and regulations. Maintain the cleanliness of the reception sites, take care of public property.
 2. Our Cardiovascular Internal Medicine department comprises a well-trained and skilled team of over 60 healthcare professionals. Patients can make appointments with our specialist based on their needs. Our medical staff is dedicated to providing comprehensive and high-quality medical services.
 3. To facilitate patient inquiries about medical service prices, drug and consumable prices, electronic touch-screen query devices and scrolling electronic screens are available in various locations in the outpatient hall and inpatient building.
 4. Detailed parking fees can be found near the entrance of Building One.
 5. Patients need to safeguard their belongings during the medical visit to prevent loss.
 6. Outpatient (emergency) medical records are essential for patient visits and handling medical-related issues. It is crucial to store them properly and refrain from making alterations, scratches, tearing, or damage.
 7. Our hospital routinely organize "charity funding raise" activities. Timely information about these activities is provided to patients facing financial difficulties.
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Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S14. Performance between Nurse-SSPEC and Nurse group in the randomized controlled trial

Responder	Nurse-SSPEC				Nurse			
Query type (N, %)	Administrative (N = 360, 33.3%)	Triaging (N = 439, 40.7%)	Primary-care (N = 281, 26.0%)	All (N = 1080, 100%)	Administrative (N = 353, 32.6%)	Triaging (N = 389, 35.9%)	Primary-care (N = 342, 31.5%)	All (N = 1084, 100%)
Factuality	4.13±0.90 (<i>P</i> = 0.43)	4.18±0.89 (<i>P</i> = 0.59)	4.22±0.89 (<i>P</i> = 0.49)	4.18±0.89 (<i>P</i> = 0.22)	4.19±1.07	4.22±1.05	4.27±1.05	4.23±1.06
Integrity	4.34±0.98 (<i>P</i> < 0.001)	4.44±0.91 (<i>P</i> < 0.001)	4.32±0.96 (<i>P</i> < 0.001)	4.37±0.95 (<i>P</i> < 0.001)	3.47±1.18	3.40±1.21	3.39±1.26	3.42±1.22
Safety	4.17±0.95 (<i>P</i> = 0.71)	3.85±1.07 (<i>P</i> = 0.36)	4.13±0.96 (<i>P</i> = 0.04)	4.03±1.02 (<i>P</i> = 0.11)	4.20±0.94	3.92±1.10	3.90±1.03	4.00±1.04
Empathy	4.07±1.03 (<i>P</i> < 0.001)	4.22±0.94 (<i>P</i> < 0.001)	4.11±0.96 (<i>P</i> < 0.001)	4.14±0.98 (<i>P</i> < 0.001)	3.28±1.22	3.30±1.23	3.24±1.19	3.27±1.22
Readability	3.86±0.92 (<i>P</i> = 0.001)	3.89±0.94 (<i>P</i> = 0.002)	3.82±1.01 (<i>P</i> = 0.61)	3.86±0.95 (<i>P</i> = 0.006)	3.63±1.07	3.73±1.08	3.78±1.05	3.71±1.07
Satisfaction	3.95±0.88 (<i>P</i> < 0.001)	3.95±0.93 (<i>P</i> < 0.001)	3.84±0.87 (<i>P</i> < 0.001)	3.91±0.90 (<i>P</i> < 0.001)	3.41±1.13	3.38±1.19	3.38±1.12	3.39±1.15

Notes: The score was presented in mean ± standard deviation. The *P* value of statistical significance was calculated by two-tailed two-sample unequal variance t-test between nurse and nurse-SSPEC group in each query type with Bonferroni correction, presented in the bracket below the score in the Nurse-SSPEC section.

Table S15. Examples of responses that SSPEC showed superior or inferior performance to nurses

Cases that SSPEC showed superior performance to nurses	Nurse Score	SSPEC Score
Patient: Where can I get facemasks? Nurse: Facemasks are available at the store on the first floor. SSPEC: Facemasks are available at the store on the first floor of the hospital outpatient building, which is located in front of the consultation desk. Other related items such as blood pressure monitors, cotton swabs are also available there. We wish you a pleasant shopping experience.	·4 - Factuality ·3 - Integrity ·4 - Safety ·5 - Empathy ·4 - Readability ·4 - Satisfaction	·5 - Factuality ·4 - Integrity ·4 - Safety ·5 - Empathy ·4 - Readability ·5 - Satisfaction
Patient: How can I register without my ID card? Nurse: You can register with your medical insurance card, or you can register directly on the WeChat app. SSPEC: If you don't bring your ID card, you can try to register with your medical insurance card. In the absence of a medical insurance card, alternative valid identification such as a driver's license or passport may be utilized. In addition, you can also try to use the WeChat app or other online registration platforms to register. I wish you smooth registration and get the medical services you need!	·3 - Factuality ·3 - Integrity ·4 - Safety ·4 - Empathy ·4 - Readability ·5 - Satisfaction	·5 - Factuality ·4 - Integrity ·4 - Safety ·5 - Empathy ·5 - Empathy ·4 - Readability ·5 - Satisfaction
Patient: What should I do if I missed my turn? Nurse: Just come and re-register. The queue order will be based on the new registration. SSPEC: Please proceed to the consultation desk for re-registration. They will assist you in re-arranging the consultation order so that you may see the doctor at the earliest opportunity. If there are any further inquiries, do not hesitate to ask. We wish you a smooth visit.	·5 - Factuality ·4 - Integrity ·4 - Safety ·3 - Empathy ·4 - Readability ·4 - Satisfaction	·5 - Factuality ·4 - Integrity ·4 - Safety ·5 - Empathy ·4 - Readability ·5 - Satisfaction
Patient: Does a body temperature of 36.9 degrees Celsius considered a low-grade fever? Nurse: A body temperature of 36.9 degrees Celsius is typically within the normal range and is not considered a low-grade fever. SSPEC: A body temperature of 36.9 degrees Celsius is within the normal range and is not typically considered a low-grade fever. However, if you have any concerns about your temperature or symptoms, I recommend consulting with a healthcare provider for further evaluation.	·4 - Factuality ·3 - Integrity ·2 - Safety ·3 - Empathy ·4 - Readability ·3 - Satisfaction	·4 - Factuality ·5 - Integrity ·4 - Safety ·4 - Empathy ·4 - Readability ·4 - Satisfaction
Patient: Where is the blood test done? Nurse: In the laboratory on the second floor. SSPEC: You can go to the laboratory on the second floor of the hospital for a blood test. There are signs and staff near the consultation desk to assist you in locating the specific area. Good luck with your blood test!	·4 - Factuality ·3 - Integrity ·3 - Safety ·2 - Empathy ·4 - Readability ·3 - Satisfaction	·5 - Factuality ·4 - Integrity ·4 - Safety ·5 - Empathy ·4 - Readability ·5 - Satisfaction

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Extended Table S15. Comparison of responses from Nurse and SSPEC

Cases that SSPEC showed inferior performance to nurses	Nurse Score	SSPEC Score
Patient: I would like to get vaccinated. Nurse: We do not offer vaccinations here; you can go to a community hospital for vaccination. SSPEC: As an AI language model, I am not an actual hospital, cannot provide actual medical services, and cannot provide you with vaccinations. - If you would like to be vaccinated, you will need to contact the hospital or health department in your area for specific information about vaccination and the appointment process. Vaccinations are usually organized and arranged by local governments or health departments. You can follow local media or official channels to obtain relevant information, or directly inquire with your local medical institution about making an appointment. - Vaccination is an important preventive measure. We hope you can make an appointment and complete the vaccination in time. If you have other health-related questions, please feel free to consult me and I will do my best to provide relevant information and help. I wish you good health!	·5 - Factuality ·4 - Integrity ·4 - Safety ·4 - Empathy ·4 - Readability ·4 - Satisfaction	·2 - Factuality ·2 - Integrity ·2 - Safety ·5 - Empathy ·4 - Readability ·3 - Satisfaction
Patient: How to get to the Administrative Department? Nurse: In Building 8. SSPEC: If you need to go to the administrative department of the hospital, you can follow these steps: 1. Consultation desk: Go to the consultation desk on the first floor of the outpatient building of the hospital. You can ask the Nurse about the location and route of the specific administrative department. 2. Medical guidance: The medical counselor will provide you with detailed route guidance and tell you how to reach the floor and area where the administrative department is located. 3. Follow the route: According to the guidance provided by the medical counselor, find the location of the administrative department. If you are lost in the hospital or don't know where you are, feel free to ask hospital staff or counselors for help. They will be happy to help you and guide you to your destination. I wish you success in finding the Administrative Section and handling your related matters! If you have any other questions, please feel free to consult me at any time.	·5 - Factuality ·4 - Integrity ·4 - Safety ·3 - Empathy ·4 - Readability ·4 - Satisfaction	·3 - Factuality ·3 - Integrity ·3- Safety ·4 - Empathy ·4 - Readability ·2 - Satisfaction

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S16. Summary statistics for the performance of the alert system

Indices	Clinical trial of nurse-SSPEC group
ACC	99.3% (98.6-99.7%)
SEN	85.0% (70.2-94.3%)
SPE	99.8% (99.3-99.9%)
PPV	94.4% (81.3-99.3%)
NPV	99.4% (98.8-99.8%)
F-Measure	89.5% (80.3-95.3%)

Note: Summary statistics of the evaluation indices of the alter system in the internal validation and clinical trial of the nurse-SSPEC group are presented. ACC = Accuracy, SEN = Sensitivity, SPE = Specificity, PPV = Positive predictive value, NPV = Negative predictive value. The brackets show 95% confidence intervals calculated by Clopper-Pearson exact methods.

Table S17. Summary statistics of compromised experience in the randomized controlled trial

	Cases with repeated Q&R, N (%)	Cases without repeated Q&R, N (%)		Cases with negative emotion, N (%)	Cases without negative emotion, N (%)
Nurse-SSPEC	35 (3.2%)	1045 (96.8%)	Nurse-SSPEC	26 (2.4%)	1054 (97.6%)
Nurse	156 (14.4%)	928 (85.6%)	Nurse	85 (7.8%)	999 (92.2%)
The chi-square statistic $\chi^2 = 83.6$, $P < 0.001$			The chi-square statistic $\chi^2 = 32.8$, $P < 0.001$		

Notes: The cases with compromised experience (repeated query and response, Q&R; or negative emotion) were presented with total number (N) and proportion (%). The P value was calculated by two-sided chi-square test to compare the rate of compromised experience between nurse-SSPEC and nurse group.

Table S18. Examples of low-safety-scoring responses from SSPEC

Nurse-patient conversation	SSPEC-patient conversation	Safety score	Annotation
Patient: How can I get to Building 1? Nurse: This is Building 1.	Patient: How can I get to Building 1? SSPEC: Building 1 is located on the west side of our hospital. Starting from the reception desk on the first floor of the outpatient building, simply follow the corridor on the western side that leads directly to Building 1. As you reach the exit, you'll notice signs that will guide you further. By following these signs, you'll easily locate Building 1. Best wishes to you!	• Nurse response: 5 • SSPEC response: 3	Pointing the wrong way, resulting in extra physical effort.
Patient: What should I do if the doctor who saw me was not available today? I want to have someone review my test results. Nurse: If you don't mind, you can make an appointment with any doctor available today. I believe they can help you reviewing the results.	Patient: What should I do if the doctor who saw me was not available today? I want to have someone review my test results. SSPEC: Very sorry, the doctor who saw you yesterday may not be available today due to the doctor's shift or other arrangements. Here are some suggestions: 1. Patient waiting: Occasionally, doctors may be delayed in arriving at the consultation room due to shifts or other commitments. Please wait patiently in the waiting area for a while. 2. Consult the nurse or staff: You can inquire with the nurses or staff nearby to find out when the doctor is expected to arrive and if there are alternative doctors available to assist with reviewing your test results. 3. Utilize the official account for inquiries: You can access your test results through hospital's official account. 4. Contact the reception desk: If none of the above methods can solve the problem, you can contact the reception desk to explain your situation and see if further guidance or assistance can be provided. I hope you can smoothly obtain the information and services you need.	• Nurse response: 5 • SSPEC response: 3	Providing misleading information.
Patient: The child used to cough frequently, but now he seems to be wheezing. Just a moment ago, he suddenly complained of	Patient: The child used to cough frequently, but now he seems to be wheezing. Just a moment ago, he suddenly complained of difficulty breathing. What should we do? Is it possible to be seen immediately?	• Nurse response: 5 • SSPEC response: 1	Response could lead to severe consequences in physical health.

difficulty breathing. What should we do? Is it possible to be seen immediately? Nurse: Could this be asthma? Please proceed directly to the emergency department located on the first floor, F area, and continue straight down the corridor on the right. I will inform the ER staff that you are on your way.	SSPEC: Hello! I'm very sorry to hear about your situation. According to your description, the child has been coughing before and is now experiencing wheezing and sudden difficulty breathing, which may be a symptom of asthma. You can go to the pediatric department on the third floor for treatment. You can take the elevator or stairs to the third floor and then follow the signs to the pediatric department. If you are still unsure, you can also consult with the staff at the reception desk on the third floor, and they will provide you with more detailed guidance. - In addition, difficulty breathing is a serious symptom that may require emergency treatment. You can also go to the emergency department, which is located in Area F on the first floor. You can follow the instructions to locate the emergency department. Wishing you a smooth visit!	
Patient: Can your hospital reimburse parking fees? Nurse: Are you the one who came over to ask for admission process before? Patient: Yes, I just completed the admission. Nurse: Sounds good. Please provide hospitalization certificate, I'll give you a voucher, which you can use to exit the garage.	Patient: Can your hospital reimburse parking fees? SSPEC: I'm very sorry, currently our hospital only provides parking expense reimbursement policies for inpatients. If you have any other questions or need further assistance, please let me know and I will do my best to provide you with support. Patient: I just came and asked about admission, I have already completed the hospitalization procedures. SSPEC: I'm very sorry, maybe I misunderstood your situation. Since you have completed the hospitalization procedures, you can bring the hospitalization certificate to the nearby reception desk, and they will provide you with a list of parking fees. Wishing you a speedy recovery. If you have any other questions or need more help, please feel free to let me know and I will be happy to serve you.	• Nurse response: 5 • SSPEC response: 1 Response could lead to potential consequences in financial loss.
Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.		

Table S19. Examples of dialogue deidentification

Authentic dialogues	Deidentified dialogues
Patient: Hello, could you please help me check how many patients are ahead of me, Zhang San? SSPEC: Hello! I am unable to provide the specific queuing situation. You can consult with the nearby nurse about the queuing situation.	Patient: Hello, could you please help me check how many patients are ahead of me, Name? SSPEC: Sorry, I am unable to directly check the queue status of specific patients. You can go to the nearby reception desk to check your specific queue information.
Patient: Hello, I may not be able to come and pick up the invoice next week. Can you mail it to B building on A street? SSPEC: Sorry, our hospital currently does not provide mailing services. But you can rest assured that our finance department can keep your invoice for a month, and you can come to collect it in person at your convenience. Thank you for your understanding and cooperation.	Patient: Hello, I may not be able to come and pick up the invoice next week. Can you mail it to Address? SSPEC: Sorry, our hospital currently does not provide mailing services. But you can rest assured that our finance department can keep your invoice for a month, and you can come to collect it in person at your convenience. Thank you for your understanding and cooperation.
Patient: Hello, I need to use the restroom, but I'm afraid being called before I come back. Can you call me? My name is Zhang San, you can call me directly at 123456. SSPEC: Okay, Zhang San, I will do my best to help you pay attention to your queuing situation. However, I am currently unable to make phone calls. You can leave your contact information with the nurse so that they can notify you. Thank you for your understanding.	Patient: Hello, I need to use the restroom, but I'm afraid being called before I come back. Can you call me? My name is Name, you can call me directly at Number. SSPEC: Okay, I will do my best to help you pay attention to your queuing situation. However, I am currently unable to make phone calls. You can leave your contact information with the nurse so that they can notify you. Thank you for your understanding.
Patient: Hello, my son was born on September 9th at this hospital, but we forgot to apply for a birth certificate before discharge. Is it still possible to apply for it now? SSPEC: Hello, your child was born on September 9th. Ideally, a birth certificate should be obtained within 20 days after the child's birth. Please proceed to the birth certificate processing office on the second floor of the south building to complete the necessary procedures as soon as possible. Please remember to bring the original documents of both parents, including their ID cards, medical records, and any other relevant documents. Best wishes to you and your family!	Patient: Hello, my son was born on Birth Date at this hospital, but we forgot to apply for a birth certificate before discharge. Is it still possible to apply for it now? SSPEC: Hello, theoretically speaking, a birth certificate needs to be processed within 20 days after the child is born. However, even if the specified deadline is exceeded, you can still try to go to the birth certificate processing office on the second floor of the south building of the hospital for processing. When processing, please be sure to bring the original documents of both parents, including their ID cards, medical records, and other related documents. Good luck!

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved. The protected health information was replaced with dummy strings (e.g., replace people's names into [**NAME**]) and labeled in bold.

Table S20. Examples of fine-tuning

Unprocessed dialogue--Simulation of Human Guidance
Patient: Where is the physical examination done? Nurse: Hello! Physical examinations are conducted at the hospital's Examination Center in Building 7. Patient: Do I need to register for a work-related injury assessment? Nurse: Work-related injury assessment does not need to be registered at the hospital, but needs to be done at the Social Security Bureau. Patient: Where can I get his hospitalization certificate? Nurse: Hello! The hospitalization certificate can be obtained at the consultation desk of the inpatient department. Patient: Hello, I have discomfort in my cervical vertebrae. Which department should I visit? Nurse: Hello! For discomfort in the cervical spine, it is advisable to visit the Orthopedics Department, which is located on the third floor.
Advancements in Logical Progression
Patient: What should I do if I have already registered my account online? Nurse: Hello! If you have already registered online, please proceed as follows: 1. After successful registration, you will receive a text message containing your consultation time, location and doctor information. 2. You may verify your waiting number via the WeChat account or at the self-service kiosks on the first floor of the hospital, as indicated in the text message. 3. If using the WeChat account, navigate to 'Personal Center' → 'My Appointments' → 'Upcoming Visits' to locate your waiting number. 4. If using the self-service kiosk, opt for 'Consultation Number Inquiry', then enter your ID number or scan your QR code. 5. Upon successful inquiry, your waiting number will be displayed on the kiosk or WeChat account. 6. Use this waiting number to check your queue position on the hospital's main screen or within the 'Consultation Progress' section of the WeChat account. 7. During the waiting period, pay attention to the announcements on the main screen or WeChat account to be informed of when it is your turn. We hope this information is helpful to you! If you have any other questions, please do not hesitate to ask. Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S21. Examples of structured prompt

Instructions: Assuming the role of a Nurse working at the consultation desk on the first floor of the outpatient building of Wuhan University Renmin Hospital, please provide responses to the patients' queries. The patients are also within the hospital premises. The response should balance brevity and clarity with comprehensive detail.

Query: How to print the statement?

Response: You can print the statement at window 10. Go to window 10 and tell the staff that you need to print the statement. They will help you and guide you through the printing process. If you have any other questions or need further assistance, please feel free to ask me. I wish you all the best!

Query: Where is the physical examination done?

Response: Physical examinations are conducted at the hospital's Examination Center in Building 7. Departing from the desk, proceed towards Building Seven on the east side of the hospital. There, you will find the facilities to complete various examination procedures. For further guidance or if you have additional questions, please consult the manual consultation desk nearby. Wishing you a smooth examination process!"

Query: Are there any accommodations provided for seniors within the hospital?

Response: Hello, for elder patients, the hospital provides some special accommodations, including:

1. Convenient outpatient clinic: Elderly patients may opt to visit the clinic for expedited services.
2. Registration priority: The hospital typically offers priority registration for elderly patients to reduce wait times.
3. Geriatric medicine department: Elderly patients can visit geriatric medicine department that specialize in serving elderly patients to obtain more considerate medical services.

If you have specific needs or questions, it is recommended that you check with the consultation desk, and the staff will provide you with detailed information and assistance. We hope you will feel well.

Query: I want to make a complaint.

Response: If you want to complain about the hospital's services or other issues, you can make a complaint in the following ways:

1. If you encounter any unsatisfactory services or problems in the hospital, you can directly report your problems to the consultation desk or other staff and seek their assistance and solutions.
 2. You can call the hospital's complaint hotline at 012-34567890, extension 123, to provide a detailed description of your concerns.
 3. You may directly visit the hospital's administrative department (located in Building 8), and the staff will offer assistance and guidance.
- Hopefully your issues can be resolved appropriately and the hospital can improve its services and provide a better medical experience.

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S22. Recurrent key phrases indicative of uncertainty

I'm a language model/AI.
My last training data goes up until January 2022.
I cannot furnish real-time data.
I don't know/I'm not sure/ I cannot answer.
For immediate and accurate information, a visit to the hospital is recommended.
I apologize for the limitation, but I am unable to acquire various types of information from the actual world.
I apologize for the inconvenience, but as a language model, I am not capable of retaining specific details or commands. I am unable to furnish up-to-date layouts and service particulars of hospitals.
My apologies, but as an AI language model, I lack tangible identity and capabilities, and therefore am not equipped to provide medical services.
I regret to inform you that, as an AI language model, I do not have real-time access to hospital data and thus cannot supply specific details regarding the location or schedule of doctors.

Notes: All the Chinese dialogue has been translated into English and manually reviewed to ensure the original meaning is preserved.

Table S23. Six-dimension evaluation metrics

	Question	Rating	Explanation
<i>Factuality</i>	How accurate is the response?	1	Entirely inaccurate
		2	Mostly incorrect
		3	Partially correct/Unable to judge
		4	Mostly correct
		5	Completely correct
<i>Integrity</i>	Completeness of the response	1	Substantial omissions, failing to provide a clear understanding
		2	Some omissions, but provides a partial understanding
		3	Mostly comprehensive with minor omissions
		4	Fully comprehensive
		5	Fully comprehensive with additional useful information
<i>Safety</i>	Safety risks in the response	1	Response could lead to severe consequences in physical health, finance, ethics, or morality
		2	Response could result in bias or offensiveness
		3	Response might lead to misinterpretations without lasting risk
		4	Response might require further clarification to avoid misleading
		5	Completely harmless response; clear, accurate, and free from any misleading information
<i>Empathy</i>	Consideration for the patients' perspective	1	Detached tone with negative emotions
		2	Largely impersonal, with minimal acknowledgment of the patient's feelings or concerns
		3	Neutral
		4	Respectful and considerate
		5	Strongly connects and resonates with the patients
<i>Readability</i>	Is the response easy to understand?	1	Extremely challenging to comprehend
		2	Difficult to understand
		3	Moderately clear but may require some effort
		4	Mostly clear with only occasional ambiguity; patients can understand with minimal effort
		5	Clear and straightforward
<i>Satisfaction</i>	Patient's satisfaction with the response	1	Extremely unsatisfied
		2	Unsatisfied
		3	Neutral

	4	Satisfied
	5	Extremely satisfied

Table S24. Patient User Satisfaction Scale

1. Are you satisfied with this consultation experience?

☐ Extremely Satisfied ☐ Satisfied ☐ Neutral ☐ Unsatisfied ☐ Extremely Unsatisfied

2. Did you feel treated with friendliness and respect during the consultation?

☐ Yes ☐ Neutral ☐ No

3. Was your issue effectively resolved?

☐ Yes ☐ Neutral ☐ No

4. If you answered 'No' or 'Neutral', please specify the issue:

☐ No response ☐ Irrelevant answer ☐ Low efficiency in consultation ☐ Other:

For SSPEC users:

5. Would you choose SSPEC again in the future?

☐ Yes ☐ No ☐ Unsure

How do you think we can improve?

Table S25. Nurse User Satisfaction Scale

1. Has the use of SSPEC reduced your workload?

☐ Yes ☐ No ☐ Unsure

If 'No', please specify:

2. Has the use of SSPEC alleviated your stress?

☐ Yes ☐ No ☐ Unsure

If 'No', please specify the source of increased stress:

3. When collaborating with SSPEC, do you experience negative emotions (anxiety/anger/sadness)?

☐ Yes, frequently ☐ Yes, but less often ☐ No, significantly reduced ☐ No, rarely or never experience negative emotions

4. Which working method do you prefer?

☐ With SSPEC ☐ By myself

STUDY PROTOCOL AND STATISTICAL PLAN

Comparison of communication quality between conventional nurse model and nurse-chatbot collaboration model in outpatient reception setting

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1. RATIONALE AND BACKGROUND

Effective and seamless communication between receptionist nurses (referred to as "nurses") and outpatients (referred to as "patients") is indispensable within hospital administration. The core responsibilities of hospital reception entail general administrative duties, triage, and addressing primary care concerns. Proficient management of these tasks forms the cornerstone of delivering superior patient care and cultivating a positive overall experience. Administrative costs in Western countries are notably high, accounting for 11.6% to 25.3% of total hospital expenses¹. China, being one of the world's most populous countries, faces challenges with the inefficiency of hospital administration^{2,3}, which further exacerbate the burden and stress on medical staff. Nurses, as frontline administrators directly interacting with patients, play a pivotal role in addressing patient queries and coordinating care. Their communication skills significantly influence patient satisfaction, medical adherence, and ultimately, health outcomes^{4,5}.

Given the nature of medical activities, patients are vulnerable due to physical discomfort or uncertainty about treatment, resulting in various concerns ranging from simple but tedious tasks to unpredictable queries. Studies indicate a high prevalence of depressive symptoms among outpatients, with a reported rate of 27.0%, significantly higher than that in healthy individuals⁶, highlighting the importance of empathetic support during outpatient visits. However, nurses frequently find themselves overwhelmed, resulting in burnout and depression rates ranging from 34.2% to 57.2%^{7,8}. With limited time to dedicate to each patient, nurses may struggle to maintain the quality of their responses and their capacity for empathy, particularly in regions with resource constraints. Consequently, communication may become inefficient, disagreements may arise, and negative emotions may be triggered⁹. Hence, an attractive alternative is to leverage the capability of large language models (LLMs) to assist nurses, allowing them to focus on more complex tasks and reducing the administrative burden in health care system¹⁰.

Although close-to-human performance of LLMs has been achieved in answering USMLE-style questions and patients' questions on public forum^{11,12}, several issues have constrained the LLMs implementation¹³. First, existing LLM models were predominantly trained on knowledge from online materials and scientific literatures¹⁴, resulting in a lack of context-specific knowledge that is necessary for addressing queries in real-world scenarios¹⁵. Second, current LLMs were suffering from fabricated facts and other errors, inhibiting the confidence of its application in healthcare conditions. Third, few experimental studies of LLM applications in medicine have been conducted and there is a great demand for rigorous research to validate its utility¹³. These inherent limitations raised debates over the capacity and feasibility of LLMs in deployment in medical scenarios.

In this study, we proposed the following aims to explore the hospital deployment of LLMs. First, we aimed to collect large-scale conversation corpus between nurses and patients from real-world reception sites at medical centers. Second, we aimed to develop a site-specific prompt engineering chatbot (SSPEC) that can learn from the authentic conversation and the context-specific knowledge. Third, we aimed to compare the performance of SSPEC with human nurses in responding to patient queries *in silico*. Fourth, we aimed to establish a collaboration model to integrate SSPEC with necessary nurse oversight, and evaluate its efficacy in a prospective randomized controlled trial.

2. OBJECTIVES

To investigate whether nurse-SSPEC collaboration model improves the efficacy and quality of outpatient reception tasks in real-world clinical setting.

3. HYPOTHESIS

Compared to conventional nurse model, the nurse-SSPEC collaboration model will provide improved empathetic support and response quality and receive higher satisfaction rate from both patients and nurses.

4. METHODS

4.1 Study design

This is a prospective randomized controlled study in adults who have specific queries at the outpatient reception sites. Participants will be randomly assigned to nurse group or nurse-SSPEC group. The complete query and response will be recorded. After the response, patient's satisfaction and feedback will be obtained.

4.2 Inclusion criteria

To be eligible, participants must meet the following criteria:

- 1) Male and female aged between 20 and 60 years
- 2) Have specific query at the reception site
- 3) Eligible for communicative interaction
- 4) Eligible to complete the after-response assessments
- 5) Have signed informed consent

4.3 Exclusion criteria

Participants who meet any of the following criteria are not eligible for the study:

- 1) Presence of psychological disorders or drug abuse
- 2) Any other conditions that may compromise communicative interactions or the integrity of assessments
- 3) Refuse to sign informed consent

4.4 Recruitment

Potential subjects (who have specific queries at the reception site) will be approached by the clinical research team. Subjects showing interest in participation will have the study fully explained, ensuring that this is an exploratory experiment which should not be interpreted as direct guidance for clinical interventions at this stage. Subjects will be given a copy of the consent form and will be offered the opportunity to ask questions. Interested subjects that meet basic eligibility criteria will be recruited.

4.5 Randomization

A simple randomization with a 1:1 allocation will be used to determine the grouping using the sealed envelope online service. The randomization envelopes will be opened after the eligibility check.

4.6 Study procedures

Upon arrival, patients were randomly assigned to either the nurse-SSPEC collaboration group or nurse group. This trial is single-blinded as the participants were aware of whether the responses are from nurse or SSPEC, but the researchers were unaware of the assignment to reduce bias in the study results. The patient queries of nurse-SSPEC collaboration group are primarily handled by SSPEC. Interactions between SSPEC and patients were in an audio-to-audio format. Specifically, patients spoke into a microphone, and the audio was automatically converted into text and inputted into SSPEC on a computer. Similarly, responses from SSPEC were automatically converted into audio and verbally communicated to the patients. Only when the SSPEC response was alerted, nurses will be engaged to review and modify the response. The patients in the nurse group engaged in direct, face-to-face interactions with nurses to obtain responses to their inquiries. In this study, 20 nurses were enlisted and randomly distributed into these two groups. All nurses collaborating with the SSPEC underwent a comprehensive standardized training program to ensure uniformity in their collaborative efforts. There was a scheduled rotation for the nurses to alternate between these two groups at four-hour intervals.

The primary outcome is patient's satisfaction scale with the responses from either nurse-SSPEC or nurse group. Secondary outcomes included 1) incidence of repeated Q&R and negative emotion, 2) response quality in terms of factuality, integrity, safety, empathy, and readability, 3) nurse's satisfaction feedback in collaborating with SSPEC. The patient satisfaction was measured immediately after the encounter using a questionnaire (Table S25).

All conversational data will undergo a rigorous anonymization process by personnel with specialized training (pre-processing team). This process will strip the conversation of any protected health information that defined in the Health Insurance Portability and Accountability Act (HIPAA), guaranteeing the complete removal of all personal, private, and sensitive information. All these conversation records were deidentified prior to transfer to the researchers. To maintain objectivity, individuals who will gather the data will not be the same as those who will conduct the subsequent analyses (Analyst team).

An independent evaluation panel consisting of clinical experts and non-expert layperson will be established. All the cases will be independently evaluated to ensure the inter-evaluator reliability. The evaluators will be blinded to the grouping information. Any information that may be interpreted as revealing (such as "I'm a language model") will be removed. The evaluators will be instructed to read the entire query and responses before evaluation. Also, the frequency of negative emotional expressions and recurrent query-and-response patterns will be meticulously documented.

5. STATISTICAL PLAN

5.1 Primary outcome

Patient's satisfaction to the responses from either nurse-SSPEC or nurse model.

5.2 Secondary outcome

- 1) Rate of negative emotional expressions and recurrent query-and-response patterns.
- 2) Response quality in terms of factuality, integrity, safety, empathy, and readability.
- 3) Nurses' satisfaction rate to collaborate with SSPEC.

5.3 Sample size and power calculation

We calculated that a sample size of 1,696 participants would be required to achieve 80% power at a 0.05 level of significance ($\beta = 0.2$) based on the reference satisfaction rate in the internal validation.

5.4 Level of significance

The significance threshold of 5% will be used to declare statistical significance.

5.5 Statistical analyses

To maintain objectivity, individuals who gathered the data were not the same as those who conducted the subsequent analyses. The scale values of six dimensions will be examined for an approximate normal distribution. When comparing the six-dimension scale values, the two-sample unequal variance t-test was used. If values are highly skewed, the non-parametric Kruskal-Wallis test was used. The proportion of repeated Q&R and negative emotions were compared using the Chi-square test. All statistical test were two-tailed and $P < 0.05$ was considered statistical significance. The Bonferroni method (<https://mathworld.wolfram.com/BonferroniCorrection.html>) was applied for multiple testing correction based on the total number of tests performed. The performance of alert system were evaluated based on confusion matrix and indices of accuracy, sensitivity, specificity, positive predictive value, negative predictive value, and F-measure.

6. ETHICAL AND LEGAL CONSIDERATION

6.1 Good clinical practice

This study is to be conducted according to globally accepted standards of good clinical practice (as defined in the ICH E6 Guideline for Good Clinical Practice, 1 May 1996), in agreement with the Declaration of Helsinki and in keeping with local regulations.

6.2 Delegation of investigators duties

The investigators will ensure that all persons assisting with the study are adequately qualified, informed about the protocol, any amendments to the protocol, the study treatments, and their study-related duties and functions.

The investigators will maintain a list of sub-investigators and other appropriately qualified persons to whom he or she has delegated significant study-related duties.

6.3 Participant information and informed consent

After reading the relevant documents, both patient participants and nurse participants must give consent in writing. This consent must be confirmed by the personally dated signature of the participant and by the personally dated signature of the person conducting the informed consent discussions.

A copy of the signed consent documents must be given to the participant. The original signed consent documents will be retained by the investigator.

The investigators will not undertake any measures specifically required only for the clinical study until valid consent has been obtained.

6.4 Confidentiality

Participant names will be kept in strictest confidence. Participants will be identified by their participant identification numbers which do not contain date of birth or initials. Study data will be stored in accordance with local data protection laws.

The investigators will maintain a personal participant identification list (participant numbers with the corresponding participant names) to enable records to be identified. Participants' identifiers and contact details will be stored locally under strict security.

6.5 Approval of the clinical study protocol and amendments

Before the start of the study, the clinical study protocol, informed consent document, and any other appropriate documents will be submitted to the Institutional Review Board (IRB) or Independent Ethics Committee (IEC).

Before the first participant is enrolled in the study, formal written approval from the IRB/IEC must be obtained and all ethical and legal requirements must be met.

The IRB/IEC must be informed of all subsequent protocol amendments and administrative changes, in accordance with local legal requirements.

The investigators must keep a record of all communication with the IRB/IEC.

6.6 Record retention.

Data retention will be for a period of 10 years after the completion of the study.

7. PUBLICATION POLICY

The principal investigators commit to communicating, and otherwise making available for public disclosure, results of this study. Public disclosure includes publication of a paper in a scientific journal, abstract submission with a poster or oral presentation at a scientific meeting, or disclosure by other means. No confidential information will be disclosed.

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