

**Design and Development Report - A Social Robot as a Health Educator for Heart Failure
Patients Using the Teach-Back Method**

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Introduction

Heart failure (HF) is a chronic, progressive cardiovascular condition that necessitates patients to engage in complex self-care behaviors to keep their condition stable and to prevent unnecessary hospital readmissions. Patients must understand their prescribed medication regimens, dietary restrictions such as lowering their sodium intake, fluid intake monitoring, symptom recognition indicating their condition is worsening, and important lifestyle modifications in order to effectively manage their condition. Despite the known importance of patient education in HF management, many patients do not possess a complete understanding of their disease process and self-care responsibilities.

In rural healthcare settings, such as those found in Southeast Kansas, there are additional barriers to effective HF education, including clinician time constraints, limited access to specialized educational resources such as intensive cardiac rehabilitation, and a wide range of deficits in patient health literacy. These challenges contribute to a performance gap between the knowledge patients should possess regarding HF management and the knowledge they actually retain following hospital discharge and subsequent clinical encounters.

This project builds upon the previously described instructional design proposal and focuses on the design and development of a novel HF patient education interaction prototype delivered by the Furhat social robot using the teach-back method. The purpose of this phase of the project is to develop instructional objectives, describe the instructional content and delivery process, outline a pilot testing strategy, and present a prototype example of the training solution.

Performance Objectives

Instructional objectives for this project were developed using the principles of performance objective design described by Dick and Carey. Objectives are organized into two levels: a terminal objective that describes the overall learning outcome and the enabling objectives that identify the specific knowledge and skills HF patients should demonstrate.

Level I Objective (Terminal Objective)

After completing the Furhat social robot instructional interaction, learners will demonstrate improved understanding of the identified HF self-care management principles associated with effective disease monitoring and self-care management.

Level II Objectives (Enabling Objectives)

Following the Furhat social robot instructional interaction, learners will be able to:

1. Explain the basic concept of HF using plain language.
2. Identify common signs and symptoms indicating worsening of condition in HF.
3. Describe the importance of medication adherence in HF management.
4. Explain the role of sodium restriction in preventing fluid retention.
5. Describe the importance of daily weight monitoring.
6. Identify the appropriate actions to take when symptoms of HF worsen.

The objectives align with crucial learning objectives included in HF education programs that are recommended by the major U.S. cardiovascular organizations. The American Heart Association (AHA) and the American College of Cardiology emphasize patient self-care education as an essential part of comprehensive HF management (Heidenreich et al., 2022). Current guidelines recommend that patients understand medication adherence, sodium restriction, symptom monitoring, and timely reporting of worsening symptoms. Additionally, patient education should promote self-efficacy that empowers individuals with HF with the knowledge and skills necessary to manage their condition (Stahlman et al., 2023). These domains correspond with those concepts assessed by the Atlanta Heart Failure Knowledge Test Version 2 (Reilly et al., 2009).

Description of Instructional Content

The instructional content will focus on the crucial concepts of HF self-management required for patients to be able to maintain clinical stability and quality of life while avoiding preventable hospital readmissions. The educational topics included in the instructional human-robot interaction prototype include:

- A basic explanation of HF
- Fluid overload and edema
- Sodium restriction
- Medication adherence
- Daily weight monitoring
- Recognizing worsening symptoms
- Knowing when to contact a healthcare provider

HF instructional content will be delivered through a conversational, face-to-face interaction between the learner and the Furhat social robot. Each instructional section will introduce a core concept using plain language devoid of medical jargon and simplified explanations that are designed to accommodate diversity in learner health literacy levels.

Description of Instructional Materials

The social robot instructional HF skill prototype consists of several elements that are designed to support the social robot-mediated HF educational interaction. The instructional materials developed for this project include:

- A conversational dialogue script programmed using the Furhat SDK
- Teach-back prompts that are embedded throughout the instructional sequence
- Expressive facial animations and gestures used by the robot to enhance engagement and to mimic human-like turn-taking during patient health education
- Structured dialogue states that guide the learner through each instructional topic
- Evaluation instruments designed to measure learner comprehension

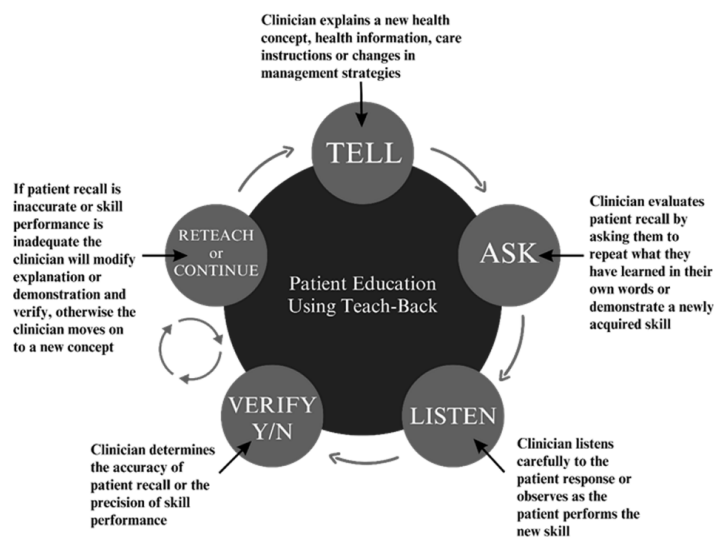
The interaction will follow a highly structured conversational flow in which the robot introduces a HF topic, asks a teach-back question, evaluates the learner's response, and provides reinforcement or clarification before moving to the next instructional topic. An example of the instructional HF skill prototype developed for this training solution is provided in Appendix A. The appendix includes a diagram illustrating the dialog flow of the robot interaction, an example snippet of the Furhat robot dialogue script demonstrating the teach-back instructional strategy built into the skill, and a link to the full HF education social robot skill GitHub repository used to implement the instructional prototype.

Instructional Method Justification

The instructional method used in this project is the teach-back method, an evidence-based strategy used in healthcare education to verify patient understanding. The teach-back method asks learners to explain newly acquired information in their own words in plain language, allowing educators to confirm comprehension and address misunderstandings immediately (Yen & Leasure, 2019). Research indicates that the teach-back method improves patient understanding of complex health information and may reduce preventable hospital readmissions among individuals with HF (Oh et al., 2021). Effective HF management requires patients to consistently perform complex self-care behaviors. Teach-back is an effective healthcare instructional strategy to reinforce patient learning and ensure comprehension. The conversational interaction designed for the Furhat social robot follows the teach-back instructional cycle illustrated in Figure 1.

Figure 1

Teach-back Method in Patient Education



Note. Diagram for the teach-back method adapted from *Teach-Back Effective Communication and Understanding*, by Great Plains Quality Innovation Network, n.d.

(<https://greatplainsqin.org/blog/teach-back-i-effective-communication-and-understanding/>).

Justification for Training Solution and Choice of Media

The Furhat social robot was selected as the instructional delivery platform for this project because it supports face-to-face conversational exchanges that mimic human-to-human interaction using both verbal and non-verbal communication. Social robots can effectively simulate aspects of human interaction through the use of facial expressions, eye contact and other gaze behaviors, and gestures during communication. By using an embodied conversational agent, it is possible to support the instructional process by allowing learners to engage in natural dialog while demonstrating their understanding of key concepts through teach-back. Mayer (2014) suggests that embodied social agents may enhance learning by incorporating social cues that encourage both engagement and motivation. Additionally, social robots may offer a potential solution to address the time constraints faced by healthcare providers by delivering standardized educational interactions while still allowing clinicians to focus on patient care that is individualized.

Pilot Study Plan

The pilot phase of this project is intended to test the functionality and instructional efficacy of the social robot HF health education prototype. Due to logistical constraints, including privacy concerns in recruiting HF patients during the project timeline, volunteers matching the demographics of typical HF patients in Southeast Kansas will interact with the robot to simulate HF patients.

Participants will engage in the social robot HF instructional interaction and respond to the teach-back prompts. Observations will focus on the following:

- Clarity of instructional explanations
- Learner responses to teach-back questions
- Conversational flow and timing
- Technical performance of the social robot interaction

Feedback gathered during the pilot phase will inform revisions to the social robot skill design before potential future implementation in a clinical setting.

Evaluation Plan

Evaluation of the social robot HF health educational prototype will include both formative and summative assessments.

Formative Evaluation

Formative evaluation will occur during pilot testing of social robotic interaction. Observations of the participant responses to the teach-back prompts will help identify those areas where instructional explanations require clarification or modification. Any technical issues related to speech recognition, conversational flow, or timing will be documented and addressed during the refinement process.

Summative Evaluation

Summative evaluation will focus on measuring learner understanding of HF and self-care management concepts. The AHFKT-v2 will be used as the primary evaluation instrument. The AHFKT-v2 is a validated assessment tool that has been designed to measure patient knowledge in HF pathophysiology, medications, diet, symptom recognition, and self-care behaviors (Reilly et al., 2009). The test will be administered before and after the social robot instructional interaction to evaluate any knowledge changes in HF following the robot-mediated HF education encounter.

Conclusion

This phase of the project focuses on the design and development of a prototype instructional intervention that utilizes the Furhat social robot to deliver HF education using the teach-back method. By integrating sound instructional design principles with emerging social robotics technology, this project explores a novel approach for improving HF patient education in healthcare settings. The development of this instructional prototype represents an important step toward evaluating how social robots might support patient education, enhance health literacy, and potentially reduce preventable hospital readmissions associated with HF while at the same time supporting clinicians and optimizing their workflow.

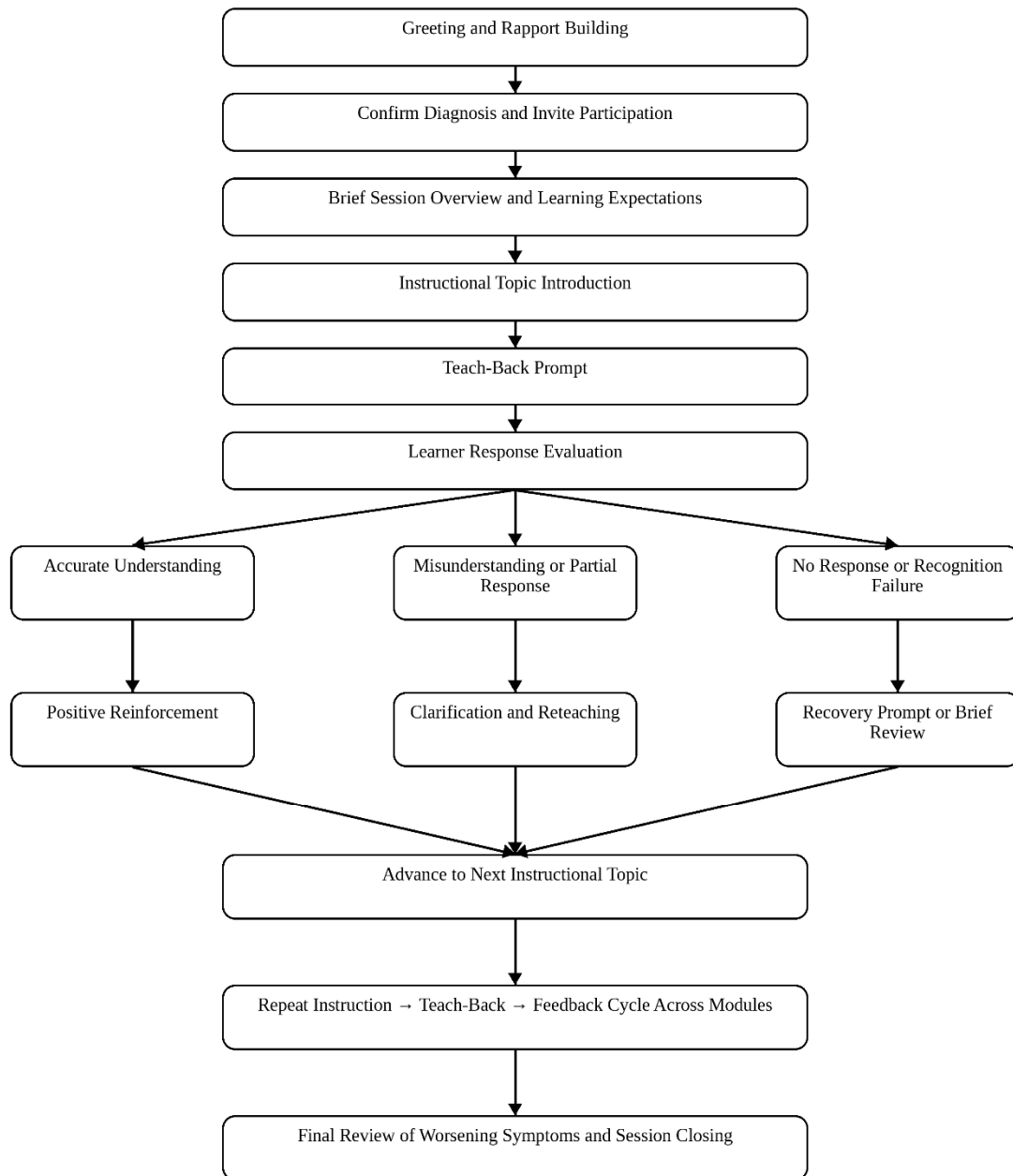
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Appendix A: Instructional Prototype for the Furhat Robot HF Education Skill

Figure A1*Dialog Flow Overview of the Furhat Robot Instructional Interaction*

Note. The diagram illustrates the conversational flow used in the Furhat robot instructional interaction

Example A1

Robot Dialogue Script Example

```

1289 // State: Diuretics
1290 // Purpose: Describe the nature and purpose of diuretics in the management of heart failure.
1291 val Diuretics: State = state(global) {
1292     onEntry {
1293         furhat.userSpeechStartGesture = listOf(Gestures.Thoughtful(strength = 0.4), Gestures.Nod(strength = 0.3), Gestures.Smile(strength = 0.2))
1294         furhat.prominenceGesture = listOf(Gestures.Thoughtful(strength = 0.4), Gestures.BrowRaise(strength = 0.3), Gestures.Mod(strength = 0.3))
1295         furhat.isAttendingUser
1296         // Explain the function of diuretics in managing heart failure and fluid buildup
1297         furhat.say("Diuretics, often known as 'water pills,' help reduce fluid buildup in the body.")
1298         furhat.gesture(Gestures.Nod(strength = 0.3))
1299         delay(300)
1300         // Provide additional details on how diuretics relieve symptoms associated with fluid retention
1301         furhat.say("They are used in heart failure to help remove excess fluid from the body, reducing swelling and easing breathing.")
1302         furhat.gesture(Gestures.Surprise(strength = 0.5))
1303         delay(500)
1304         // Mention common diuretic medications to make the information more relatable
1305         furhat.say("Common diuretics include furosemide, hydrochlorothiazide, and spironolactone.")
1306         furhat.gesture(Gestures.Smile(strength = 0.5))
1307         // Emphasize the importance of taking diuretics as prescribed for effective management of heart failure
1308         furhat.say("Taking diuretics as prescribed helps prevent fluid overload and hospitalizations.")
1309         furhat.gesture(Gestures.Nod(strength = 0.5))
1310         delay(500)
1311         // Ask the user a question to assess their understanding of diuretics
1312         furhat.ask("Let's see how well I have explained this medication. Could you tell me why it's important to take your diuretics as prescribed?", timeout = 30000, endSil = 2000)
1313         furhat.gesture(Gestures.Thoughtful(strength = 0.5, duration = 0.7))
1314     }
1315
1316     // Handle correct response, providing positive feedback and transitioning to the next topic
1317     onResponse<Diuretics> {
1318         furhat.ledStrip.solid(java.awt.Color.GREEN)
1319         furhat.say("That's right! Diuretics help your body get rid of excess fluid, which can reduce swelling and ease breathing.")
1320         furhat.ledStrip.solid(java.awt.Color.BLACK)
1321         furhat.gesture(Gestures.Smile)
1322         furhat.gesture(Gestures.Nod(strength = 0.7))
1323         // Reinforce the value of diuretics in preventing hospitalizations due to fluid overload
1324         furhat.say("This can help prevent fluid buildup and reduce the risk of hospitalization.")
1325         delay(300)
1326         // Move to the next topic about exercise
1327         furhat.say("Awesome effort! Now, it's time to discuss the importance of exercise and the role it plays in heart failure management.")
1328         furhat.gesture(Gestures.Thoughtful(strength = 0.4))
1329         delay(500)
1330         goto(ExerciseHeartFailure)
1331     }
1332
1333     // Handle incorrect or incomplete response, providing additional guidance and explanation
1334     onResponse<NotDiuretics> {
1335         furhat.ledStrip.solid(java.awt.Color.YELLOW)
1336         furhat.say("Good try! Let's go over it again.")
1337         furhat.ledStrip.solid(java.awt.Color.BLACK)
1338         furhat.gesture(Gestures.Shake(strength = 0.5))
1339         delay(300)
1340         // Explain the purpose of diuretics in heart failure management in simpler terms
1341         furhat.say("Diuretics, or water pills, are important because they help your body get rid of excess fluid. This reduces swelling and helps you breathe more easily.")
1342         delay(300)
1343         furhat.say("By taking your diuretics as prescribed, you can prevent fluid overload and avoid hospitalization.")
1344         furhat.gesture(Gestures.Thoughtful(strength = 0.4))
1345         delay(500)
1346         furhat.say("Awesome effort! Now, it's time to discuss the importance of exercise and the role it plays in heart failure management.")
1347         furhat.gesture(Gestures.Smile(strength = 0.4))
1348         delay(500)
1349         goto(ExerciseHeartFailure)
1350     }

```

Repository Access

Full Furhat Skill Implementation

GitHub Repository:

<https://github.com/ifishdoyou/Furhat-Robot-Heart-Failure-Education>

This repository contains the complete Furhat robot skill implementation, including the dialog states, conversational logic, and instructional flow used in the HF teach-back interaction.

Appendix B: Atlanta Heart Failure Knowledge Test



ATLANTA HEART FAILURE KNOWLEDGE TEST (AHFKT-V2)

Baseline Knowledge

1. Heart failure is a problem in which:

- ☐ There is too much blood in the body
- ☐ The heart is unable to pump enough blood
- ☐ The blood vessels in the heart are clogged
- ☐ The heart skips beats

2. Which of the following statements about heart failure is **TRUE**

- ☐ It can be cured with drugs and other treatments.
- ☐ A person with heart failure cannot live a normal life.
- ☐ Heart failure cannot be cured but it can be controlled.
- ☐ Heart failure means the heart has stopped beating.

3. People with heart failure can do many things to help themselves. Think about each of these activities and decide if they would be **helpful** for someone with heart failure. Please check those activities that would be **helpful**.

- ☐ Avoid salty foods
- ☐ Drink lots of fluids
- ☐ Stop smoking
- ☐ Drink alcoholic drinks each day to relax
- ☐ Skip heart failure medicines when they feel better
- ☐ Know when to call the doctor or nurse for symptoms of heart failure

4. ACE inhibitors (ex. Capoten, Vasotec, Lisinopril, or Zestril) are medications used to treat heart failure. These drugs help the heart pump stronger by:

- ☐ Removing extra fluid and salt from the body
- ☐ Causing blood vessels to get smaller
- ☐ Blocking the harmful effects of stress hormones
- ☐ Improving blood counts (reducing anemia)

5. People who have heart failure take diuretics (Lasix, "water pills") so that:

- ☐ Their kidneys will make more urine and pass more water
- ☐ Their heart will beat more steady
- ☐ The blood vessels in their body will widen or relax
- ☐ Their heart will pump stronger

6. People with heart failure who are taking a diuretic ("water pill") need to:

- ☐ Know if they need to take extra potassium with their water pill
- ☐ Take the diuretic after 3-4 p.m. in the day
- ☐ Not worry about signs and symptoms of dehydration
- ☐ Drink lots of water to replace lost fluid

7. If a person with heart failure gains 2-3 pounds in a few days, this usually means he/she:

- ☐ Is eating too many calories and gaining weight
- ☐ Has extra water in the body
- ☐ Needs to drink more fluid
- ☐ Needs to be getting more exercise to burn calories

8. How often should a person with heart failure weigh themselves?

- ☐ Every day
- ☐ Every week
- ☐ Every month
- ☐ Once in a while

9. The best time of day for persons with heart failure to weigh themselves is:

- ☐ At bedtime
- ☐ Upon awakening in the morning
- ☐ At or around lunchtime
- ☐ When they remember to do it

10. Persons with heart failure should call their doctor if they have which of the following symptoms?

- ☐ Weight gain of 2-5 pounds in 1-2 days
- ☐ Increased swelling of the ankles and/or stomach
- ☐ More shortness of breath
- ☐ All of the above

11. How often should a person with heart failure exercise?

- ☐ Every week
- ☐ Every day
- ☐ Several times a day
- ☐ 2-3 times per week

12. A person with heart failure should stop and rest when doing physical activity if:

- ☐ They feel short of breath or winded
- ☐ They have chest pain or discomfort
- ☐ They feel dizzy or lightheaded
- ☐ All of the above

13. Which is a big source of sodium (salt) in the diet?

- ☐ Processed foods (such as tv dinners)
- ☐ Smoked or cured meats
- ☐ Table salt
- ☐ All of the above

14. Which has the **LOWEST** amount of sodium (salt)?

- ☐ Fresh fruits
- ☐ Canned vegetables
- ☐ Reduced sodium soup
- ☐ Frozen dinners

15. Which food has the **MOST** sodium (salt)?

- ☐ Sliced tomato
- ☐ Broiled fish
- ☐ Baked ham
- ☐ Skim milk

16. Which dessert has the **LOWEST** amount of sodium

- ☐ Fried chicken
- ☐ Cheeseburger
- ☐ Baked potato with sour cream and chives
- ☐ Taco salad

17. Some people with heart failure are told by their doctor to limit fluids. Which of the following count as fluids?

- ☐ Water and clear liquids
- ☐ Milk, ice cream, and yogurt
- ☐ Jello, pudding, and soups
- ☐ All of the above

18. If a person with heart failure has a headache or pain, which would be the best medicine to take?

- ☐ Aspirin
- ☐ Tylenol (Acetaminophen)
- ☐ Advil or Motrin (Ibuprofen)
- ☐ Anacin Regular Strength or Excedrin

19. The recommended total daily amount of sodium that persons with heart failure should eat is:

- ☐ 3,000 milligrams
- ☐ 2,500 milligrams
- ☐ 2,000 milligrams
- ☐ 500 milligrams

20. How many servings are in the can?

Nutrition Facts		Amount/serving	%DV*	Amount/serving	%DV*
Serving Size 1/2 cup (120mL)		Total Fat 1.5g	2%	Total Carb. 8g	3%
Condensed soup		Sat. Fat 0.5g	3%	Fiber Less than 1g	4%
Servings about 2.5		Trans Fat 0g		Sugars 1g	
Calories 60		Cholest. 15mg	5%	Protein 3g	
Fat Cal. 15		Sodium 890mg	37%		
*Percent Daily Values (DV) are based on a 2,000 calorie diet.		Vitamin A 4%		Vitamin C 0%	
				Calcium 0%	
				Iron 2%	

- ☐ 1
- ☐ 2
- ☐ 2 1/2
- ☐ 3

21. How much sodium is in one serving of soup?

Nutrition Facts					
Seri. Size 1/2 cup (120mL) condensed soup Servings about 2.5		Amount/serving	%DV*	Amount/serving	%DV*
Calories 60 Fat Cal. 15		Total Fat 1.5g	2%	Total Carb. 8g	3%
		Sat. Fat 0.5g	3%	Fiber Less than 1g	4%
		Trans Fat 0g		Sugars 1g	
		Cholest. 15mg	5%	Protein 3g	
		Sodium 890mg	37%		
*Percent Daily Values (DV) are based on a 2,000 calorie diet.					
Vitamin A 4% • Vitamin C 0% • Calcium 0% • Iron 2%					

- ☐ 15mg
- ☐ 890mg
- ☐ 445mg
- ☐ 2225mg

22. A person with heart failure who is trying to limit their fluids may reduce symptoms of thirst by:

- ☐ Chewing gum or sucking hard candy
- ☐ Cutting back on their medications
- ☐ Drinking small amounts every 30-60 minutes to prevent thirst
- ☐ Warming fluids before drinking

23. If a person with heart failure forgets to take their medicine, they should:

- ☐ Take their medicines as usual the next day
- ☐ Take the medicines as soon as remembered
- ☐ Take double the dose the next day
- ☐ Call their doctor immediately

24. It is important for a person with heart failure to:

- ☐ Make sure they get the flu shot every year
- ☐ Receive the pneumovax vaccination to prevent pneumonia
- ☐ See their heart failure doctor regularly
- ☐ All of the above