Neurological observations in infants, children and young people

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Neurological Observations in infants, children, and young people – Part 2

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Abstract:	Neurological observations are a vital part of clinical assessment of the child in hospital, they are designed to identify indications of new or further brain injury. Nursing neurological observations consist of the AVPU, Glasgow Coma scale, pupillary response, and limb movement & strength assessment. The Glasgow Coma scale is a system to assess function and consciousness in patients at risk of neurological deterioration, it was originally created in 1974 by Jennett and Teasdale and was adapted by Tatman et al. in 1997 for children and infants. It has become an integral part of the clinical assessment of children with brain injuries of all mechanisms.
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Aims and Learning Outcomes

In Part one of the two-part series, we explored vulnerabilities that put children and young people at risk of head injuries, as well as exploring the pathophysiology of increased intracranial pressure and the impacts this has on children and young people with head injuries.

Part two of the Neurological Observations in Infants, Children and Young People series aims to raise awareness of the importance of accurate neurological observations on any child at risk of neurological deterioration. This includes delivery of a neurological assessments, communication and escalation of observations and problem-solving difficulties that could impact neurological observations. Connecting pathophysiology will also be explored to help tie in what was explored in Part 1.

After reading this article and completing the necessary time-out activities, you should be able to:

- Discuss the importance of consistent neurological observations in practice when caring for an infant, child, or young person.
- Explain the correct process of undertaking AVPU, Glasgow Coma Score and Pupil responses.
- Describe when it is important to escalate care when dealing with neurological deterioration.
- Discuss difficulties of assessing neurological wellbeing in an infant, child, and young person within the hospital environment.

Difficulties of assessing neurological wellbeing in infants, children, and young people within the hospital environment.

As stated in Part 1, infants and children may present as ‘well’ and then show delayed signs and symptoms of an injury hours, days or even weeks later. It is for this reason that an accurate and thorough patient history is vital to aid regular neurological observations. As such, having a family and person-centred approach can provide key information such as:

- A detailed history surrounding the wellbeing of the patient and recent events, which includes:
    - Allergies.
    - Medications.
    - Past Medical History.
    - Last time they ate.
    - Events related to the injury.
    - Account from the family or key witnesses (Mc Auley et al, 2023).

Let’s look at an example - A child or young person could present with a persistent headache. If we don’t employ professional curiosity, we could miss vital information that could help establish events relating to the headache. So, asking further questions such as:

- Any head trauma?
- Any family history? For example, migraines?
- How does the headache feel?
    - Is it a throbbing pain
    - Is it a stabbing pain
    - Is it always there?
    - Where on the head is it located, and does it radiate?
- What makes the headache better? Do they lie in a dark room?
- Is it worse lying down or standing up?
- Does the patient vomit first thing in the morning?
- Any triggers? Stress, food etc?
- Any sinus problems such as congestion?
- How is their school performance?
- Are there any other symptoms that you think may not be related to the headaches?

An ABCDE assessment is then established to detect for any signs that could increase intracranial pressure, reduce MAP, or alter neurology. Key considerations include:

- Pain can increase intracranial pressure as well as increase metabolism of neurons, which encourages oxygen consumption which can increase risk of neuronal death.
- Hypoglycaemia can alter consciousness particularly in infants. Ensure a blood glucose level is performed if there are any concerns around neurology.
- Be aware of other signs of head injuries that may present later. This includes CSF leakage from the nose and ears, bleeding from the ear canals, lacerations, and periorbital bruising (racoon eyes) (NICE, 2014)
- Any signs of cardiovascular instability such as tachycardia, reduced urine output or altered perfusion in the limbs. Take note of changes in skin colour.
- If there are other injuries, limb perfusion checks are necessary to identify signs of compartment syndrome.

Time-out activity 1- Difficulties in assessing infants, children, and young people in hospitals.

Before reading on, pause for a moment and think about key factors that could increase difficulty and inconsistency of neurological observations within a hospital setting.

Accurate assessment of neurological observations allows early identification of deterioration and prevention of secondary factors leading to neurological damage (Derbyshire and Hill, 2018). Children have many reasons in comparison to adults requiring neurological treatment and are at high risk for deterioration. If these are not identified early, this can lead to life-limiting impacts and in severe cases, death (Holland and Brown, 2021) Therefore, it is key for nurses to hone and maintain their neurological nursing assessment.

Nursing competence and confidence in assessing neurological status will vary among nurses and may be dependent upon on their level of qualification and exposure to neurosurgical patients. Mattar et al. (2014) highlighted nurses who were experienced (in neurological assessments) viewed neurological assessment positively, were more competent and confident, in comparison to newly qualified nurses and nurses who lacked neurosurgical exposure.

Nursing competency and confidence is essential when assessing children and young people neurologically however this is not only limited when performing the 'skill' but also key when educating parents and families.

To improve accuracy amongst nursing staff and to prevent further harm to paediatric patients it is crucial to embed and improve neurological assessment competency. Robinson (2015) identified the need to improve neurological assessment in all ages across the paediatric population and innovated a tool that assesses across five age groups which significantly improved neurological assessment accuracy. Similarly, Hill et al (2017) identified the lack of accuracy in assessing neurological observations on the paediatric population and implemented a training scheme which led to a positive outcome amongst child nurses. Further literature (Cook et al. 2019) seeks to advertise the need for standardising neurological assessment across settings and continuing the training will further improve nursing competency.

NHS England (2018) have identified an improvement resource to support safe staffing which includes skill mix in acute wards of children and young people (CYP). This resource is aimed at the CYP setting overall and suggests that on a ward setting one nurse to four patients or one nurse to three patients if a child is under 2. However, it does not consider the high level of nursing required by certain specialities such as neurosurgery. There must be further research into the staffing levels and skills mix of paediatric neurosurgical nursing to allow development of these nurses which will further positively impact patients as competence and confidence will grow among them.

A consistent approach to neurological assessments is recommended to improve the accuracy and interpretation of neurological assessments (Figure 1).

Figure 1 shows the recommended approach to neurological observations (Glasgow Coma Scale, 2015):

Check	Check for factors that could interfere with the patient's ability to communicate or interact with you. Examples include medication given, injuries, underlying neurological conditions, language barriers etc.
Observe	Observe from a distance what they are doing. Have they got their eyes open? Are they interacting with you, family members or other

	health professionals? What is their left and right movement like?
Stimulate	If required, use necessary verbal or pain stimuli to trigger the patient's best response, thus measuring their awareness and arousal.
Rate	Rate their best response on the chart

Handover of the way we have observed and interpreted neurological observations is crucial to maintain consistency of neurological observations. When handing over to a new nurse or other health professional such as a nursing associate, it is important to perform a full set of neurological observations at the time of handover. This will ensure that the staff member taking over the care of a patient agrees with your judgement and as such adds consistency to the care of the patient.

Family centred care is a crucial aspect in children's nursing as it recognises the significance of the caregivers, but it must be recognised that they need emotional and psychological support from nurses (Caus et al, 2020). Families who are dealing with intense and usually a sudden onset of neurological condition will struggle to understand the complexities involved and often need educating about what the nurses are doing and why (Manskow et al, 2018).

Identifying neurological deterioration is the responsibility of the nurse however empowering families and patients to do so enhances care and can improve the care delivery as families know the 'norm' of the child or young person prior to neurological deterioration.

A personal example of where this has proved to be useful is when assessing neurological status of a young person post operatively following neurosurgery. The young person was referred to as their 'legal name' and had been preoperatively with no issues. However, post operatively she was more sleepy than usual and assessing response was vital, therefore I called her using her 'legal name' several times and there was no response. At her bedside was her mother and brother who looked concerned but remained calm, I asked the brother if he would try calling her as a familiar voice might help, he did but used a 'home name' which was completely different, but the patient responded swiftly and told her brother 'Let me sleep!' Thereafter a positive neurological assessment was made as response levels were determined to be of no issue as the patient co-operated as family were involved and the familiarity of loved ones eased the process.

It is known that parental anxieties can increase in a hospital setting (Weis et al, 2015) which can contribute to parents forgetting or having difficulty in expressing

important feelings and information (Goubert et al, 2012). Home names are common for many ethnic minorities and start at a very young age therefore children's nurses must work closely at building therapeutic relationships and be culturally competent (De and Richardson, 2022). This can be established by communicating effectively and with families and demonstrating a passion to learn and integrate. Communicating why we assess GCS and that it is crucial they let us know of any useful information such as 'home names' to prevent worry and assist neurological assessment.

Time-out activity 2:

- **Reflect upon a similar experience you may have had when assessing neurological observations or any nursing care that was impacted by your lack of knowledge on the cultural attributes of the family.**

Performing neurological assessments on children and young people

Neurological observations play a crucial role in a full body assessment in children and young people who are at risk of neurological deterioration, whether caused by trauma or non-traumatic reasons, or underlying conditions that could impact neurological deterioration.

As outlined in Part 1, the development of children and young people, paediatric nurses require children's nurses to take a modified approach to neurological observations. This considers:

- Communication ability.
- Ability to localise to stimuli (motor co-ordination).
- Cognitive development.
- Self-awareness.

Physiologically, neurological observations are designed to assess the ability of the nervous system to manage sensory and motor information through-out the body. A particular structure that is necessary for the coordination of neural activity is the reticular formation.

The reticular formation is a complex network consisting of a network of brainstem nuclei and neurons that act as a major integration and relay centre for numerous imperative brain systems to coordinate functions essential for survival. The name ''reticular'' correlates to the functions of integrating, coordinating, and influencing a variety of regions within the central and peripheral nervous systems. The vast network of neurons of the reticular formation influence functions such as arousal, consciousness, circadian rhythm, sleep-wake cycles, coordination of somatic and motor movements, cardiovascular and respiratory control, pain modulation, and habituation. The reticular formation relates to most parts of the CNS and although it has generalised influence within the CNS, it additionally holds subsystems that are directly involved in specific functions. The most clinically significant aspects are:

- Cardiac and respiratory centres in the medulla
- Descending systems in the pons and medulla that are involved in motor control and influence muscle tone
- Ascending pathways in the upper pons and mid-brain that contribute to consciousness
- The ascending reticular activating system (ARAS) associated with the sleep wake cycle and wakefulness
- Locus ceruleus – the primary site for where norepinephrine is released

Injuries to areas of the brain can cause differentiation in the presentation of children and young people with head injuries, but ultimately any part of the brain injured can interfere with transmission of vital neural signals between neural pathways in the brain and resulting neural pathways from the reticular formation to other parts of the body.

AVPU

AVPU is a basic assessment of consciousness and stands for **A**lert, only responsive to **V**oice, only responsive to **P**ain, **U**nresponsive (Hoffmann et al, 2016). AVPU provides nurses with the most sensitive measure of consciousness, as we would expect our patients to be fully awake and responding to questions. It is for this reason that for any child who is hospitalised, AVPU is advised to be part of a full body assessment and recorded on the PEWS chart (see Figure 2). It is critical that the patient is assessed when fully awake and should not receive a lower score for being asleep.

Figure 2 shows the AVPU scale used in clinical practice

A	Alert and fully aware. Can easily be aroused or woken up
V	Responds to voice. Acceptable to shout to initiate a response
P	Responds to appropriate pain stimuli if not responsive to voice
U	Unresponsive to appropriate pain stimuli

Glasgow Coma Score (GCS)

GCS is best analysed as a trend to assess whether the patient is improving or deteriorating, to accurately establish this trend an initial GCS should be carried out

on admission and a baseline GCS should be determined. The scale gives the child a score of 3 – 15, 3 being the lowest score and 15 being the highest. A score of 3 indicates a completely unresponsive child and 15 being of normal neurological function.

As discussed in Part 1, neurological deterioration indicates increased intracranial pressure which can disrupt neural activity and thus impact a child and young person's consciousness, cognitive and arousal ability. Regular GCS monitoring can indicate the severity of intracranial hypertension, which in turn can lead to brain herniation which would be seen in lower GCS scores.

Shalaby, Reda and Emam (2019) explains how scoring comprises of three parts; Eye opening response (Figure 3), verbal or grimace response (Figure 4) and motor response (Figure 5), the score from each part is added up to give an overall GCS. Verbal response should be used as standard unless the child is usually non - verbal or has an artificial airway such as a tracheostomy or endotracheal tube that would impair their ability to speak.

Before carrying out a GCS, it is best practice to talk to the parents and establish the child's normal ability, what they are like at home when they are well. This is particularly important for children and young people who have complex conditions that could cause global developmental delay. Spending time explaining the GCS procedure with the family is critical to allow understanding of the purpose of the assessment. Family members can also provide guidance on how to best stimulate their child to improve the accuracy of the GCS.

GCS should be assessed when the child is fully awake, a sleeping child should not receive a lower score, wake the child up and start your assessment.

Figure 2 - Eye Opening Response

Response	**Older Children**	**Infants**
4 - Eyes open spontaneously	The patient is awake and opening their eyes spontaneously	As older children
3 - Eyes open to voice	The patient will only open their eyes when you say their name or talk to them	As older children
2 - Eyes open to pain	The patient will only open their eyes when painful stimuli is applied	As older children
1 - No eyes opening response	There is no eye opening in response to verbal or painful stimuli	As older children

Figure 3 - Best Verbal Response

Response	Older Children	Infants
5 – Orientated	The patient can accurately answer questions and coherently talk to you	Alert, babbles, coos, words or sentences to usual ability
4 - Confused	The patient may be confused as to where they are or what happened	Less than usual ability or spontaneous irritable cry
3 – Inappropriate words	The patient will answer questions with words that are not	Cries to pain
2 – Inappropriate sounds	The patient cannot form words and will just make sounds	Moans to pain
1 – No verbal response	No response to pain	No response to pain

FOR PATIENTS WITH ALTERED VERBAL ABILITY SUCH AS HAVING A TRACHEOSTOMY, THE GRIMACE SCORE SHOULD BE USED:

Response	Older Children	Infants
5 – Normal facial activity	The patient has normal facial movements and normal oromotor (movement of the mouth) activity	As older children
4 – Decreased facial activity	Decreased facial activity or decreased oromotor activity	As older children
3 – Vigorous grimace	Only on activity or when painful stimuli is applied the patient will grimace vigorously	As older children
2 – Mild grimace	Only on activity or when painful stimuli is applied the patient will only exhibit a mild grimace	As older children
1 – No facial activity	No response to pain	As older children

Figure 4 - Best Motor Response

Response	Older Children	Infants
6 - Obeys commands	The patient will squeeze your hand or move when asked	Normal spontaneous movements and withdraws to touch
5 - Localises to pain	When painful stimuli is applied the patient will use their limb to actively try and remove the source of pain	Reduced spontaneous movements but withdraws to touch

4 - Withdraws to pain	When painful stimuli is applied the patient's only response will be to try and withdraw their limb or head from the area in which painful stimuli is applied	As older children
3 - Flexion to pain	This is decorticate posturing in response to painful stimuli (see figure 1) when painful stimuli is applied the arms are drawn into the centre of the trunk and the hands turn inwards	As older children
2 - Extension to pain	This is decerebrate posturing (see figure 1) when painful stimuli is applied the arms extend and the hands turn outwards	As older children
1 - None	No response to command or application of painful stimuli	As older children

Time-Out activity 3

Neurological observations are keenly observed by parents who are anxious about the changing state of their child's health. How might you explain 'doing observations' to recognize the psychological and the support needs of the patient or child?

The Motor response section of the GCS chart is a key indication of the level of brain injury and should be escalated immediately if the score drops by 1 point. When assessing motor response painful stimuli should be applied firmly if the child is not obeying commands. There are two types of posturing that are indicative of increasing intracranial pressure that is causing brain herniation, decorticate and decerebrate posturing (Figure 5).

Figure 5 shows the decorticate and decerebrate posturing

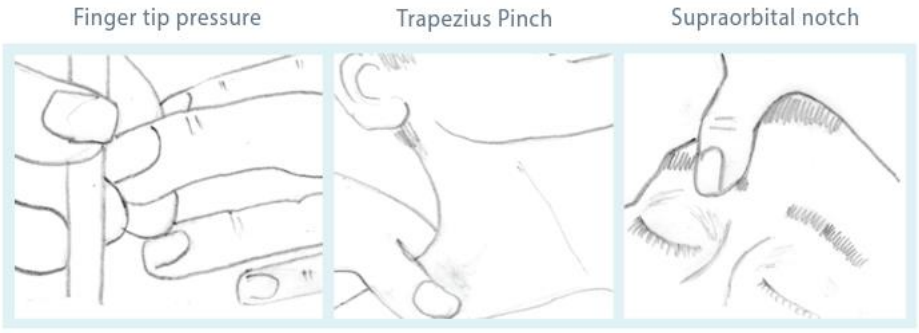
Decorticate posturing in a child presents as flexed and rigid arms that are usually drawn into the centre of the trunk, clenched fists with rigid flexed feet. This is a sign that there is damage to the motor cortex in the brain where the Corticospinal tract originates. In turn, the motor signals sent through the Corticospinal tract into the spinal cord are damaged, causing unimpeded activation of the Ruberospinal tract which causes flexion in the muscles (Knight and Decker, 2022).

Decerebrate posturing in a child presents as rigid, extended arms and rigid, flexed feet and is indicative of damage to the brain cortex extending down into the medulla and pons in the brain stem. The part of the brain where Corticospinal tract and the Ruberospinal tract is now damaged and not sending signals down the spinal cord meaning the Vestibulospinal tract, that controls extension, is now unimpeded (Whitney and Alastra, 2022). This indicates that the injury is now extending into the brain stem, progression from decorticate to decerebrate posturing is usually a preterminal sign of tonsillar herniation (coning).

The use of painful stimuli when assessing GCS can be difficult, and it is not yet universally agreed which the of painful stimuli should be used in children. Prior to administering painful stimuli, consider applying gentle stimuli such as performing a blood pressure or squeezing their hand or asking their parent to talk to them as they are more likely to respond if able.

If this doesn't work it's vital to apply the right painful stimuli to elicit the most accurate response without causing unnecessary injury, your trust policy should be referred to when deciding what type of painful stimuli to apply. There are two types of painful stimuli used, central and peripheral, peripheral stimuli is finger/nail bed pressure and can be used in the first instance as it comes with the least risks, although it can sometimes trigger a spinal reflex and not a purposeful response. If the patient does not respond, then supra orbital pressure should be applied which involves putting pressure on the bony ridge at the top of the eye. This should be avoided in children with facial fractures or children who have had surgery around this area. If this fails to elicit a response or you cannot apply this technique, squeezing the trapezium can be done in children but it should be escalated to a medic if you are having to use this kind of painful stimuli to get a response from your patient.

Figure 6 shows the locations of the recommended pain stimuli



In paediatric settings, sternal rub to elicit a pain response is contraindicated, children have a soft sternum and rubbing here can cause bruising and cardiac arrhythmias,

although medics may decide to use this when assessing a deteriorating patient that is not responding to any other techniques. There is no national guidance on what type of painful stimuli should be used in children, however local policy should be followed to maintain safety. Caution should always be used when applying any type of painful stimuli, not to cause any unnecessary bruising or injury and if the patient is responding to voice, painful stimuli is not needed.

Motor responses can still be obtained even if a patient has quadriplegia. The Glasgow Coma Score is about assessing a patient's understanding and awareness, as well as their arousal and alertness. As such, you can get around the motor response assessment by asking the patient to stick their tongue out. If they understand what you are saying, it shows good cognition in their motor response.

It is also important to note that changes in motor response differ in children/young people to infants, as due to immature motor cognition, infants are unable to localise to painful stimuli from birth to 6-12 months. As such, observing for spontaneous movement and application of touch to feet and hands to test for responses is advised.

Time-Out activity 4

Discuss with one or more colleagues now how you have approached the ethical issues relating to eliciting painful stimuli in a child. What part did parental or guardian consultation play? Was it easy to explain the importance of such a test at a given time?

Further Neurological Assessments

Limb assessment

It is important when assessing the limbs that not only grip and strength are assessed but whether the patient has any anti-gravity movement. Anti-gravity movement refers to the patient's ability to lift their arms or hands from a resting position into the air, rather than just being able to move them around on the bed. Ask the patient to squeeze your hand and use their foot to push against your hand, both the left and right limbs should be assessed regularly and compared, new onset weakness in one or both sides should be escalated.

Pupillary response

As part of your neurological observations, the regular checking of pupillary response is vital and an important indicator of new onset injury if the reaction or size of the pupil changes. Pupil size and response is our most sensitive marker for increased intracranial pressure, as increased intracranial pressure can disrupt pupillary sphincter muscle stimulation. Cranial nerve III (oculomotor nerve) plays a particular role in pupil constriction in response to increasing light, to protect the delicate retinas. As part of a parasympathetic response, cranial nerve III triggers pupilloconstrictor muscles to reduce the size of pupils to limit light exposure. The optic nerve plays a crucial role in transmitting sensory information from

photoreceptors in the retina, triggering the pupillary reflex response (Adoni and McNett, 2007).

To correctly check the pupils, both eyes must be opened first. Check the size of the pupils before stimulating with a light. Take note of the size of each pupil and use a pupillary scale to compare. Both pupils should be equal. A bright pen torch is then used to shine into the eye bringing the light from the outside of the eye inwards. Pupils should have a brisk reaction to light, indicating the optic nerves that travel through the brain to the occipital lobe are intact and not impeded by pressure (Jevon, 2008).

If the reactivity has become sluggish or there is no reaction is either one or both the pupils this is an indication that there is new or evolving injury that could be related to:

- Increasing pressure on the optic nerve.
- Increasing pressure on cranial nerve III (oculomotor nerve).
- Increasing pressure on the efferent pathways.

Any changes in pupil size and response should be escalated immediately and treated as an emergency. New onset fixed and dilated pupils are an emergency in all cases and is often a sign that the brain stem is herniating, this should be escalated immediately to a medic. It is important to establish in patients what their pupils look like normally, for example, some children with brain tumours may have a known lesion that will cause pupillary dysfunction.

Time-Out activity 5

Completion of neurological observations.

Have a look at the video: https://www.youtube.com/watch?v=b58zU_mjAQc which shows a neurological assessment in full. Make a note of how the pupils and limbs are assessed.

Frequency and Escalation

Neurological observations should be assessed immediately on admission to establish a baseline, your local policy should be referred to on the frequency of observation. The Royal College of Nursing (2017) standard for the minimum for the frequency of observation on admission, whether this is post operative or on presentation, is half-hourly for two hours, hourly for four hours and two-hourly once their expected baseline is achieved. Frequency of neurological observations should always be agreed with the medical team, especially if it is proposed that observation is being deescalated to less than two-hourly. If GCS drops by 1 in this initial admission period, it should be escalated to a medic and half hourly GCS should be resumed until the patient has been assessed.

Any change in neurological symptoms should be escalated immediately, as it could be the first indicator of new or further injury. Signs and symptoms include:

- Vomiting or nausea.
- Lethargy.
- An evolving headache.
- Change in pupil reactivity.
- Change in pupil symmetry.
- Agitation.
- Abnormal behaviour.
- Decrease in GCS.
- Ataxia.
- Altered personality.
- Reduced fontanelle in infants.

Local policy should be referred to when it comes to escalating a drop in GCS, The National Institute of Clinical Excellence (NICE) (2014) that recommends escalation when there is a drop in 3 or more points in the Eye Opening or Verbal scores or a drop of 2 in the Motor score. Any decrease in GCS should be immediately escalated, ask an experienced colleague to perform a GCS with you to confirm the decrease, escalate to a medic and revert to half hourly GCS assessment.

Conclusion

Consistency of neurological observations is fundamental to improving the quality of care for patients with neurological deterioration. As we conclude this two-part series, having knowledge of why we perform neurological observations physiologically, as well as understanding the pathophysiology of head injuries will ultimately lead to increased competence in neurological assessments and more effective family support and multidisciplinary team working. Correct assessment, escalation of concerns and handover of observations can reduce hospital wait times which has positive impacts on patients, families, staff, and trusts. More research is needed to further improve consistency of paediatric neurological observations, but education and communication are vital to improve consistency.

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Revisions made for Part 2

- Additional sentence added in aims and learning outcomes section.
- Learning outcomes modified.
- ‘Difficulties of assessing neurological wellbeing in infants, children and young people within the hospital environment’ section brought forward in the article to improve readability.
- Discussion surrounding importance of patient histories added to ‘Difficulties of assessing neurological wellbeing in infants, children and young people within the hospital environment’ section.
- Introductions to figures added within the text.
- Change of section name: Performing neurological assessments on children and young people.
- Additional sentence added within the GCS section.
- Change made to Time-out activity 3