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Mythology in *Kojiki*: A Medical Perspective

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Abstract: *Kojiki* is the oldest extant book written in Japanese. The *Kamitsumaki* (the upper volume) of *Kojiki* contains many Japanese myths and has been extensively studied by scholars of various fields, including history, comparative mythology, linguistics and literature. Their efforts have produced a wealth of knowledge on *Kojiki* in their respective fields. However, relatively little attention has been paid to its content by medical historians and scholars in the medical field. This paper is the first attempt at comprehensively evaluating, from a medical perspective, descriptions regarding the myths in the *Kamitsumaki* of *Kojiki*, including sex and childbirth of Izanagi and Izanami, the death of Izanami, Izanagi's escape from the land of Yomi, Ama-terasu's concealment in the Amano Iwato, and Saku-ya-bime's delivery. The paper not only proposes new interpretations of the myths, but also shows that the *Kamitsumaki* of *Kojiki* contains a wealth of narratives that relate to a broad range of medical disciplines, providing us with insight into the ancient Japanese people's medical practices and understanding of medical phenomena. Furthermore, many of the medical narratives and practices described in *Kojiki* have scientific rationales. The paper demonstrates that *Kojiki* is an indispensable resource for research on medical history in Japan.

Key words: medical history, *Kojiki*, Japanese myths, *kegare*, *ubuya*

Introduction

Completed in 712, *Kojiki* is the oldest extant book written in Japanese. Along with *Nihon shoki*, *Kojiki* is considered one of the most important texts in providing a wealth of knowledge and insight into the early period of Japan. While *Nihon shoki* was written in Chinese to serve as an authenticated history of Japan, *Kojiki* was written in a combination of Chinese and *manyogana* and targeted domestic readers. According to the preface of *Kojiki*, the book was initially commissioned by Emperor Tenmu (reign 672–686) to "correct" the errors in the content of *Teiki* and *Kyuji*, which were circulating among the nobles at the time. The compilation of *Kojiki* stalled after the death of Emperor Tenmu, but in 711, Empress Genmei ordered a court scholar named Ono Yasumaro to compile *Kojiki* based on Hieda No Are's memorized stories. The purpose of compiling *Kojiki* was to corroborate the legitimacy and authority of the emperor and royal family in their rule over Japanese society at the time, especially during the tumultuous period after the Jinshin War. The *Kamitsumaki* (the upper volume) consists of Japanese myths and covers the foundation of Japan by the deities, ending with the descent of Emperor Jimmu, the first emperor and the descendent of Ama-terasu-o-mi-kami, the sun goddess, to earth from heaven. The *Nakatsumaki* (the middle volume) covers the conquest of Jimmu from Takachiho, located in Kyushu to the east, and ends with the fifteenth emperor, Ojin. The *Shimotsumaki* (the lower volume) records the lineage of the imperial family from the sixteenth emperor to Empress Suiko.

Recent studies in comparative mythology have revealed that many of the myths in the *Kamitsumaki* can

be classified according to their “northern” and “southern” origins.[1–3] Myths rooted in the north share similarities with Greek and Scythian myths as well as those of the Korean Peninsula, while myths rooted in the south share similarities with those in such areas as the Jiangnan region of China, Southeast Asia, Micronesia and Melanesia. The *Kamitsumaki* of *Kojiki* has been extensively studied by scholars of various fields, including history, comparative mythology, linguistics and literature. Their efforts have produced a wealth of knowledge on *Kojiki* in their respective fields. However, relatively little attention has been paid to its content by medical historians and comprehensive evaluation of the text from a medical perspective is lacking. Previous evaluations by medical researchers on the medical aspects of the Japanese myths in the *Kamitsumaki* have been limited to sporadic reports on specific topics or brief essays.[4–7] Even in more comprehensive works on Japanese medical history, references to the accounts in the *Kamitsumaki* of *Kojiki*, if any, have been negligible.[8,9] Within the legendary and mythological stories in the *Kamitsumaki*, there are narratives based on historical experiences and medical actuality. The aim of this paper is to conduct a thorough evaluation and review, from a medical perspective, of the Japanese myths in the *Kamitsumaki* of *Kojiki*, thereby adding a new layer of interpretation to the existing knowledge on this valuable text and shedding light on the medical practices and understanding of medical phenomena in the early period of Japan.

Sex and childbirth–Izanagi and Izanami

The first medical description in *Kojiki* is the mention of the structural difference between male and female bodies and sexual intercourse between the two deities, Izanami and Izanagi. Here, pregnancy results in the failure to give birth to legitimate islands, and instead, they give birth to Hiruko (leech child) and then Aha jima. After the failed attempt, the two deities consult heavenly deities, and the *futo-mani* – the divination – performed by the heavenly deities reveals that the failure resulted from Izanami’s speaking first. Thereafter, the two deities succeed in giving birth to Japanese islands.

Izanagi and Izanami are described in *Nihon shoki* as children of Ao-kashiki-ne-no-mikoto, making them brother and sister. Similar myths with motifs of deluge, incestuous unions and monstrous births are also seen in areas such as Formosa, the Philippines, Borneo, southwestern China and India.[10] In a myth of the Amis tribe in Taiwan, a brother and sister survive a major flood and become husband and wife, whose resulting children are all snakes, frogs and the like. The sun god teaches them to conduct a religious ceremony, after which they bear healthy children. In southwestern China, the Miao and Yao groups also have similar tales. In their versions, a brother and sister, after surviving a massive flood, give birth to a deformed son. They dismember the son into multiple pieces, from which objects, plants and humans were created.

The reason for the initial failure is attributed in *Kojiki* to the fact that the female, not the male, initiated the conversation. Sexual practices similar to that depicted in *Kojiki* (woman on the right, man on the left, and the man speaks first) can be found in the old Chinese text *Dong Xuan Zi* from the sixth century.[11] The condemnation of Izanami for speaking before Izanagi is often interpreted as a reflection of a patriarchal ideology influenced by Chinese ideas. However, it is quite dubious that this ideology existed in the early period of Japan.[12] From a medical perspective, another interpretation needs to be considered in the context of the age of marriage in the ancient era. Although there is a dearth of data on the age of marriage before

the eighth century in Japan, like in many societies at the time, marriage was linked to fertility and occurred earlier than in modern society. In the eighth century, according to the Laws on Residence Units from the Yoro administrative code, women were allowed to marry at age 13 and men at 15.[13] This was so because the stages of puberty occur earlier in women than in men. In Japan, women's menarche occurs at approximately 12 years of age. While data regarding the age of the first ejaculation is limited, it is reported to be around age 14 in Japan.[14] These ages were likely higher in ancient Japan, as there has been a secular trend toward earlier puberty worldwide.[15] In the text of old Chinese medicine, *Huangdi Neijing: Suswen*, women and men are reported to gain reproductive ability by age 14 and 16, respectively. The initial failure of childbirth and its attribution to the initiation of sexual conversation by women may imply the age difference at which men and women gain reproductive ability.

The descriptions regarding the births of Hiruko (leech child) and Aha Jima have generated many interpretations.[16] One of the popular theories is that Hiruko was meant to be a sun ('昼' or '日')-child in pair with Hirume ("sun woman", Ama-terasu's alias). However, there are no strong arguments to explain why the Chinese character needed to be changed to a leach and unified in both *Kojiki* and *Nihon shoki*. Moreover, based on similar tales in other regions, this interpretation of Hiruko seems somewhat less convincing.[17] As it was clearly stated that Hiruko and Aha Jima were not considered to be the couple's children, they were likely failed pregnancies or fetuses with significant abnormalities.

The tales of a brother-sister marriage resulting in strange creatures are probably based on the increased risk of abnormalities seen in children of incestuous unions. In a study on children of incest, Adams reported that the frequency of death plus major defect was six in eighteen (33%) in children of incestuous unions (brother-sister and father-daughter matings).[18] Baird reported that in twenty-one children of brother-sister or father-daughter matings, twelve had abnormalities, nine of which were severe (43%).[19]

While there are similar tales in other parts of Asia, a leech is only mentioned as the product of birth in *Kojiki*, where Hiruko is written as "water leech", suggesting freshwater leeches (possibly related to paddy cultivation) rather than terrestrial species. Considering the descriptive nature of *Kojiki*, as discussed throughout this article, it is almost impossible to ignore the striking resemblance between the leech and the pregnancy tissue, or blood clots expelled vaginally in relatively early spontaneous abortions. The name "leech child" may have been inspired by actual observations of spontaneous abortions.

The name Aha Jima is intriguing from a medical standpoint. Aha (淡: faint, pronounced "apa" in Archaic Japanese) shares its pronunciation with millet (粟). Saigo suggested that this word might have been used for unspecified small islands which were like millet grains.[20] From a medical perspective, it should be noted that a hydatidiform mole has the very distinct appearance of small vesicles, which resemble cooked millet. The first extant report on hydatidiform moles in human history is believed to date back to 400 BC when Hippocrates described dropsy of the uterus. It is critical to note that the incidence of hydatidiform moles is three times greater in Japan than in North America and Europe, occurring in approximately two per 1,000 pregnancies. The risk of hydatidiform moles in women under sixteen years of age is six times greater than that of women aged sixteen to forty, as the risk increases significantly at the extremes of the reproductive age range.[21] In ancient Japan, marriages likely occurred at younger ages, which would have further increased the risk of hydatifidorm moles.

The death of Izanami

After giving birth to the fourteen islands of Japan, Izanami gives birth to thirty-five deities. She then sustains a burn injury to her genitalia after giving birth to Hi-no-kagu-tsuchi-no-kami, a fire deity, and subsequently develops problems of emesis, defecation and urination and passes away.

There are various theories regarding the birth of the fire deity and the death of Izanami. Some researchers connect the birth of the fire deity with the use of fire accompanying the shifting cultivation which is thought to have occurred in the Jomon period, while others interpret Izanami's birth of the fire deity as related to volcanic eruption.[2)] Recently, Hayakawa et al. proposed that the tale represents the incidence of local puerperal infection and subsequent sepsis,[22)] a proposal with which I concur. Furthermore, Izanami's symptomology is consistent with sepsis caused by group A *Streptococcus*. Puerperal fever has been recognized for over three thousand years in human history and was a leading cause of morbidity and mortality in parturient women. Around 1500 BC, ancient Hindus alluded to the hazards of childbed fever. In Hippocratic writing in 500 BC, puerperal fever was attributed to suppression of the lochia and the imbalance of humors. Multiple outbreaks of puerperal fever have been reported in the literature, and the death rate reached one in four or five women giving birth.[23)] Alexander Gordon, a Scottish physician, described the contagious nature of puerperal fever in 1795. Subsequently, Ignaz Semmelweiss, a Hungarian physician, discovered that hand washing significantly reduced the incidence of puerperal fever. The pathogenesis of puerperal fever remained unclear until 1879 when Louis Pasteur identified hemolytic streptococcus in the blood of a woman with puerperal sepsis. An epidemiological study by the Centers for Disease Control found that postpartum women had a 20-fold increased incidence of group A streptococcal disease compared with non-pregnant women. The increased risk of certain infections in pregnancy is thought to be due to altered innate immunity during pregnancy.[24)] In Izanami's case, the birth of the fire deity and burning of the genitals, indicating local inflammation and fever, are followed by emesis and defecation. Systemic symptoms, including gastrointestinal symptoms, are common in patients with sepsis. Gastrointestinal symptoms, such as emesis and diarrhea, are more common in patients with severe sepsis, occurring in approximately twenty per cent in one study.[25)] In a study reviewing invasive group A streptococcal infection in pregnancy, gastrointestinal symptoms were reported in forty-nine per cent of the cases.[26)] In that study, multiparous women acquired severe group A streptococcal infection more frequently than nulliparous women. Izanami is considered to have been multiparous (gravida 51 para. 49), which may have increased her risk of severe group A streptococcal infection.

The description in *Kojiki* of Izanagi's death in the process of her birth likely reflects the significant impact of maternal death, both socially and emotionally, on communities in early Japan.[27)] According to archaeological studies on death and burial during the Jomon period, women who died during pregnancy or around the time of delivery were all buried in a distinct manner, indicating that maternal death was treated differently from other forms of deaths.

The land of Yomi and the escape of Izanagi

After Izanami's death, Izanagi visits the land of Yomi and breaks the taboo of looking at Izanami's corpse, thus failing to bring her back. Similar stories are found in Greek mythology in the tales of Orpheus

and Eurydice as well as those of Persephone and Hades. While some scholars believe that there was an actual taboo against looking at a corpse, some believe there was a custom of evaluating a corpse at certain intervals to ascertain whether it had come back to life. In the old custom of *mogari* or *akari*, a corpse was kept in a dedicated room until the actual funeral.[28)]

In ancient times, it was difficult to distinguish the dead from people experiencing deep coma. In Japan, it was not until later in the Kamakura period that the pulse examination was incorporated into the confirmation of death. In earlier periods, the confirmation of death relied not only on the lack of respiration but also the putrid smell and decomposition of the body.[8)] In *Genji Monogatari*, written in the eleventh century, Murasaki Shikibu wrote that after Aoi No Ue passed away, her body was left intact for two to three days to see whether she would revive. It was only after a significant change to the clearly decaying body that people sent it to the crematory. In the ancient period, necrophagous insects colonising a fresh corpse likely helped to confirm death and to estimate the post-mortem interval. Some of the natural processes associated with decomposition, such as rigor mortis, subside within the first seventy-two hours after death.[29)] Insects play an integral role in decomposition and are helpful, not only in the first seventy-two hours but also days to weeks after the death, in estimating the time of death, as their life cycles are relatively predictable. In 1767, Carl von Linné, a biologist studying arthropods, noted the importance of insects in cadaver decomposition. Jean Pierre Mégnin, a French veterinarian and entomologist, described the chronological sequence of cadaver decomposition and insect colonisation in 1894.[30)] The analysis of insects on the decomposing remains in estimating the time since death is still used in modern medicine in the field of forensic entomology when the death occurs outside healthcare settings. Izanagi awaited his beloved's return but could no longer wait. The exact duration is not described in *Kojiki*. To my knowledge, this has rarely been discussed in the literature. Dipteria (flies) and Cleoptera (beetles) are among the most important insects in forensic entomology. In a study evaluating insect activity on human cadavers, adult blow flies were observed on the cadavers within two to three hours, and female flies were observed depositing eggs on nasal openings, ears, mouth and eyes.[31)] Hatchings of the fly eggs occurred within six to forty hours, and emerging larvae were observed feeding on the cadaver tissues. The larvae fed on decaying flesh for three to ten days and then migrated off the cadavers and buried in the nearby soil. Adult flies emerged after six to eighteen days of pupariation. In another study, larvae were seen in large numbers on cadavers two to seven days after death.[32)] Assuming that Izanami's corpse was reasonably accessible to the insects, Izanagi's waiting time was probably no more than seven to ten days.

Izanagi attempts to dispel demonic women and warriors of the dead by using grapes, bamboo shoots, sword and peaches. The flight, which involves a transformation of objects to stall the chaser, is known as the magic flight motif. Such motifs are seen in myths from various parts of the world.[1)] The passage of Izanagi's flight also explains why a certain number of people die each day.

The descriptions related to Yomi in *Kojiki* gives us important insight into the ancient Japanese view of death and the afterlife. First, as noted by Philippi,[33)] there is no concept of a final judgment or reward after death. Second, the land of the dead and death are linked to pollution and are associated with evils and disaster. Izanagi describes Yomi as a horrible, unclean land. In the process of purification, Yaso-maga-tsu-hi-no-kami and O-maga-tsu-hi-no-kami, the deities responsible for disaster, calamity and evil, come into existence from the pollution, which Izanagi takes on when he goes to Yomi. Third, human death is explained by divine influence (Izanami's curse). In the *Nakatsumaki* of *Kojiki*, the epidemics during the

reign of Emperor Sujin are said to be due to O-mono-nushi-no-oho-kami's will and divine wrath. As in many ancient societies, disease and death were deemed to have supernatural origins. In the Heian era, disease was believed to be due to *mononoke*, or evil spirits, and Onmyoji, practitioners of the art of Onmyodo, were hired to deal with the spirits.[9)]

The magic flight motifs usually involve the use of objects such as rock, water and a comb.[1)] In *Kojiki*, Izanagi throws the vine securing his hair (similar to a comb), which bears grapes, but different items are used. Grapes, bamboo shoots and peaches used to dispel the hags of Yomi and a horde of warriors of Yomi were believed to have beneficial effects on health in ancient Japan.[7)] The oldest medical book in Japan, *Ishinho*, written by Yasuyori Tamba in 984, is a compilation of a vast number of medical books at the time, including medical texts from China, which have now been lost. According to *Ishinho*, grapes were considered to have an anti-aging effect and to prolong life.[34)] The beneficial effects of grapes are now well studied in modern medicine. In particular, the phenolic compounds in grapes, including anthocyanins, flavanols, and resveratrol, have many health-promoting properties such as in functioning as antioxidant, anti-inflammatory and anticancer cardioprotective agents.[35)] Bamboo shoots were also considered to have health-promoting properties. In *Ishinho*, bamboo shoots were noted for treating diseases that caused polydipsia/polyuria (likely diabetes mellitus), for activity against "water passage (水道)" and for increasing energy.[34)]

The practice of using peaches to dispel evil spirits came from China. Peaches were also consumed to treat various conditions, including blood stagnation, coughs, an illness of the central nervous system, and were associated with longevity. *Ishinho* describes a tale of a Chinese hermit who, owing to eating peaches, was energetic at age 300. Izanagi also uses a sword in an attempt to dispel the horde of warriors of Yomi. This sword was used in early Japan for magico-religious practices to treat intermittent fevers such as malaria.[36)]

Izanagi's use of medicinal foods to escape from the evil spirits of the land of the dead concludes with a practice of *misogi*, a form of purification by cleaning the entire body in the river. The *shi-e* (death impurity) is one of the most dreaded forms of *kegare* (impurity). *Misogi*, derived from "mi (water)" or "mi (body)" and "sosogi (wash)", remains an important ritual practice of Shinto. It is unclear exactly when this practice of purification started in Japan. The third century Chinese chronicle *Wei Zhi* describes how Japanese people bathed in the river after funerals. The preventive effect of hygiene practices, especially hand-hygiene, on the transmission of pathogenic microorganisms is now well established.[37)] Izanagi's *misogi*, a process to rid pollution from the dead, is another magico-religious practice with medical benefit described in *Kojiki*. Ignaz Semmelweiss, a Hungarian physician who discovered that hand washing significantly reduced the incidence of puerperal fever, concluded that the disease was caused by "cadaverous particles." The tale of *Kojiki* implies similar concepts of illness and preventive strategy whereby dead bodies are associated with pollution and the washing of the body with the removal of pollution.

Izanagi's escape is often seen as another version of the magic flight motif, and there is relatively little analysis on why the above food and ritual practices were inserted into this tale. Maki proposed that the tale symbolizes medical victory over disease and death.[7,36)] I concur that Izanagi's escape from the spirits of the dead with the use of medicinal foods and magico-religious rite can be interpreted as the effort of a man fighting against aging, illness and death.

In the conversation between Izanami and Izanagi, we can also find a concept of rudimentary statistics

on births and deaths. The first nationwide family register in Japan, *Kogo nenjaku*, was in fact conducted in 670 under the leadership of Emperor Tenji, approximately 40 years before the compilation of *Kojiki*. Izanami and Izanagi's conversation indicates that there was a daily population increase of 500, which, based on the lunisolar calendar, translates to an increase of approximately 177,000 each year. Although this is likely an overestimate of population increase, it is important to note that there was a drastic increase in the population of the Japanese islands from the Yayoi period, when irrigated rice farming was introduced, to the Nara period, when *Kojiki* was written in the eighth century. Japan's population is considered to have fluctuated between 20,100 and 261,300 during the Jomon period but increased from an estimated 594,900 to approximately 4.5 million to six million by the Nara period, which was made possible by more stable food production.[38)]

Ama-terasu's concealment in the Amano Iwato

In the process of *misogi* in the river, Izanagi gives birth to thirteen deities, including Ama-terasu, the goddess of the sun and ancestor of the imperial family, and her brother Susa-no-o. Izanagi orders Ama-terasu and Susa-no-o to rule Takama-no-hara and the ocean, respectively. However, Susa-no-o disobeys his father and instead wishes to go to the land of his mother, subsequently being expelled by Izanagi. Before heading into exile, Susa-no-o decides to visit his sister in Takama-no-hara. Ama-terasu is wary that Susa-no-o is coming with evil intentions to usurp her lands. To prove otherwise, the deities perform *ukei*, a divination ritual. By giving birth to girls, Susa-no-o reports that he has proven his innocence, and then he carries out various misconducts, driving Ama-terasu into a cave.

The concealment of Ama-terasu in the Amano Iwato and the following festive activities conducted by the eight-hundred myriad deities to entice Ama-terasu out of the cave are ambiguous.[39)] Some researchers have argued that the event represents a solar eclipse. Many agree that these events represent *niinamesai*, the harvest festival, and *chinkonsai*, an Imperial ceremony for the propitiation of departed souls, which are held one day apart.

Multiple researchers have pointed out the striking similarities of stories related to Ama-terasu and Susa-no-o with the stories of Demeter and Poseidon in Greek mythology.[2)] Like Demeter and Poseidon, Susa-no-o and Ama-terasu are brother and sister, and Susa-no-o is depicted as emotionally labile; Ama-terasu is linked to agriculture and harvest, whereas Susa-no-o is linked to the ocean and earthquakes. Similar to the tale of Demeter and Triptolemus, wherein Demeter selects Triptolemus as the transmitter of her gift of grain and agriculture to all men, Ama-terasu bestows rice ears from the sacred garden on Ninigi, Ama-terasu's grandson, when he descends from the heaven. It is believed that parts of Japanese myths were transmitted from west to east by Eurasian nomads including the Schythians.[1–3)]

Amaterasu's concealment is often compared to Demeter's concealment in the cave after Poseidon's violence. Pausanias describes an account in Phigalia where Demeter conceals herself in a cave after being raped by Poseidon:

> Mount Elaios... has a cave sacred to Demeter surnamed Melaina.... Afterwards, they say, angry with Poseidon and grieved at the rape of Persephone, she put on black apparel and shut herself up in this cavern for a long time. But when the fruits of the earth were perishing, and the human race dying

> yet more through famine, no god, it seemed, knew where Demeter was hiding, until Pan, they say, visited Arkadia. Roaming from mountain to mountain as he hunted, he came at last to Mount Elaios and spied Demeter, the state she was in and the clothes she wore. So Zeus learnt this from Pan, and sent the Moirai to Demeter, who listened to the Moirai and laid aside her wrath, moderating her grief as well.

In a version in Arcadia told by Pausanias, Demeter is raped by Poseidon in the guise of a horse:

> When Demeter was wandering in search of her daughter, she was followed, it is said, by Poseidon, who lusted after her. So she turned, the story runs, into a mare, and grazed with the mares of Ogkios; realizing that he was outwitted, Poseidon changed into a stallion and enjoyed Demeter.

Poseidon's disguise as a horse is noteworthy, as in *Kojiki* the weaving maiden strikes her genitals against a shuttle after a horse is thrown in from the roof of the weaving hall by Sasa-no-o. In *Nihon shoki*, it is Ama-terasu herself who is injured by the act of Susa-no-o. Matsumura argued that in the original version of the myth, the victim was Ama-terasu herself, not the heavenly weaving maiden (or Waka-hiru-me in another account of *Nihon shoki*).[39)]

The theory that Ama-terasu was traumatized by Susa-no-o's sexual violence seems to be at odds with the view of Ama-terasu as the principal deity of the heaven. However, contrary to the common contemporary belief of Ama-terasu as the principal imperial ancestral deity, a careful reading of *Kojiki* and *Nihon shoki* indicates that Taka-mi-musubi, not Ama-terasu, was the principal deity in the country before the 7th century, and Ama-terasu was a local deity.[3)]

Post-traumatic stress disorder and depression are common in women after sexual assault. Approximately half of women develop moderate to severe depression after rape.[40)] People who have experienced depression often use metaphors to describe their experience, with the experience commonly characterized by darkness and being trapped in a tight space.[41)] Whether it was from Susa-no-o's misdeeds or sexual violence, Ama-terasu's concealment in the cave is likely a metaphor for her depressive state.

In order to lure Ama-terasu from her concealment in a cave, the deities assemble and perform various rites. Ame-no-uzume dances and exposes her genitals, which causes the deities to laugh at once. Ultimately, Ame-no-ta-jikara-o-no-kami pulls her out of the cave and brings back light to the world. The exposure of genitals by Ame-no-uzume is believed to be associated with Iambe's performance before Demeter in the Homeric hymns and the exposure of genitals by Baubo before Demeter in the Protrepticus of Clement of Alexandria.[2,42)] Demeter falls into a depressive state after her daughter, Persephone (Kore), is abducted and raped by Hades. She arrives at Eleusis and is welcomed by the king, Celeus. A woman named Baubo (Iambe) attempts to entertain and revitalize the goddess, but when everything else fails, Baubo "at once drew up her garments from down below and revealed to the sight the form of her privy parts". The goddess then brightens, laughs and drinks a special potion. Although it is not Ama-terasu herself who laughs in the tale of *Kojiki*, the laughter and revivification of Ama-terasu from her depressive state are clearly linked. The ritual laughter, by luring Ama-terasu from her concealment, restores light to the world. Interestingly, the Greek *gel-* root (*gelōs*: "laughter") is likely to have an etymological connection with ideas of brightness or gleaming light. Recent studies on laughter-based interventions have shown

positive physiological and psychological effects on human health.[43] Laughter can help reduce stress, anxiety and the symptoms of depression. Furthermore, Ama-terasu overcomes her depressive state through the voluntary, coordinated efforts of myriad deities gathered specifically to help her. In the end, Ame-no-ta-jikara-o-no-kami pulls Ama-terasu out of the cave, and another deity, Futo-tama-no-mikoto, prevents her from re-entering. Social support plays an important role in outcomes of depression and is also known to be a protective factor against depression.[44]

The killing of O-ge-tsu-hime

After Susa-no-o is expelled from the heaven, he meets O-ge-tsu-hime-no-kami, one of Izanami and Izanagi's children, who offers him food. Susa-no-o is enraged and kills her when the food was produced from her nose, mouth and rectum. The tale of O-ge-tsu-hime, which explains the origins of the five grains, belongs to the Hainuwele-type myths present in some other parts of the world, including Indonesia and Melanesia. The difference from the original tale, in which Hainuwele defecates valuable objects and is killed by others out of jealousy, is noteworthy. In the tale of O-ge-tsu-hime, we can observe, as in the Izanagi's *misogi* after encountering the deceased Izanami (*shi-e*), the concept of *kegare* (impurity). Food containing the bodily fluids of others was considered polluted and, therefore, something to be avoided. Indeed, in the following chapter, Susa-no-o discovers people living upstream when he sees a chopstick floating down the river. Chopsticks were not reused or shared, and there was a custom of discarding them in the river after use.[45] A similar concept of avoidance of body fluids is mentioned in the Law of Manu, part of the four sacred Vedas of Hindu scripture circa 200 BC. It states "Oily exudations, semen, blood, urine, feces, the mucous of the nose, ear wax, phlegm, tears, the rheum of the eyes, and sweat" are the twelve impurities of the human body (The Laws of Manu [5:135]).

Various scholars have attempted to explain why the concept of *kegare* developed in Japanese society. It is beyond the scope of this paper to perform an exhaustive evaluation of the concept; however, avoiding corpses and the body fluids of others, as well as the practice of *misogi*, are clearly preventative strategies against the transmission of pathogens. Food contaminated with other people's saliva and feces allow oral–oral and oral–faecal transmissions of pathogens. Human cadavers, especially of those who died with infections, can transmit deadly pathogens to people handling them.[46] There are documented cases of physicians and medical students who have died from contracting pathogens such as tuberculosis and smallpox from cadavers. In the fourteenth century, even before there was knowledge of microbiology, a Mongolian army catapulted plague-infected cadavers into the besieged Crimean city of Caffa, transmitting the disease to the inhabitants.[47] In the present day, pathogens such as Mycobacterium tuberculosis, group A streptococci, *Neisseria meningitides*, gastrointestinal pathogens, the hepatitis B and C viruses and HIV are considered to pose significant risk to those handling the cadavers of the recently deceased.[48]

While empirical wisdom may have shaped hygiene behaviour, such as seen in Shinto and other religious practices, the responses to most infectious threats have often been accompanied by sensations of disgust. According to Curtis, hygiene is partly instinctive: disgust and hygiene behaviour came first, and rationales came later.[49] One of the behavioural strategies for avoiding infection is to avoid contact with conspecifics that are likely to harbour the pathogens, which are adapted to infect the target hosts – a behaviour seen in many animals. For example, Caribbean spiny lobsters avoid conspecifics infected with the species-specific

Panulirus argus virus,[50] and bullfrog tadpoles avoid conspecifics infected with *Candida humicola*.[51] Gypsy moth larvae prefer uncontaminated foliage to cadaver-contaminated foliage, thereby decreasing infection risk.[52] House-hunting ants avoid otherwise excellent potential nest sites when they find dead conspecifics.[53]

Susa-no-o's response when the food was taken out from O-ge-tsu-hime's body seems excessive in light of religious practice. As described earlier, Susa-no-o is depicted as a very emotional deity, and thus, the tale seems to imply our innate sensation of disgust towards infectious threats, which perhaps explains this story's appeal to readers.

Descriptions of alcohol intoxication

As mentioned earlier, one of Susa-no-o's misdeeds was defecating in the sacred ceremony hall. According to *norito* for the Mina-zuki-no-tsugomori-no-o-harae (Great Exorcism of the Last Day of the Sixth Month), defecation in a sacred place was considered one of the eight heavenly sins. After committing this sin, Ama-terasu attributes Susa-no-o's behaviour to drinking, saying, "That which appears to be feces must be what my brother has vomited and strewn about while drunk". Interestingly, the first descriptions of symptoms attributed to alcohol intoxication in Japanese literature are of unpleasant effects of drinking, emesis in this case, rather than symptoms such as euphoria. Based on Ama-terasu's comment, nausea and emesis might have seemed so common that she even pardons Susa-no-o's heavenly sin. Ethanol can elicit nausea and emesis by directly inducing acute gastric mucosal injury. More importantly, especially in the Japanese population, an excessive accumulation of acetaldehyde can lead to an "alcohol-flush reaction", typical symptoms of which include facial flushing, nausea, headache and tachycardia. In humans, over 90% of alcohol is metabolized in the liver. Ethanol is first metabolized into acetaldehyde, mainly by alcohol dehydrogenase, which is subsequently oxidized into acetate, mainly by aldehyde dehydrogenase (ALDH). The *ALDH2*2* allele encodes an inactive form of the mitochondrial ALDH2, and people with the *ALDH2*2* allele show high concentrations of acetaldehyde in their blood, even after a mild dose of alcohol. Researches have shown that a significant proportion of Japanese, approximately 50% in a study, carry this allele.[54] In contrast, the *ALDH2*2* is rare in Caucasians and African populations. Individuals with *ALDH2*2* not only experience more symptoms of alcohol-flushing reaction but are also more likely to experience more intense hangover symptoms, including nausea, and are less likely to develop alcoholism, perhaps due to more aversive experiences with drinking.

In the tale of Susa-no-o and Yamata-no-orochi, an eight-headed and eight-tailed snake, Susa-no-o successfully intoxicates the snake deity with sake, easily defeating it. The tale describes the sedative effect of alcohol used against the dreaded deity in the region. Ethanol is now known to interact with various major neurotransmitter systems, including the predominant inhibitory neurotransmitter, γ-Aminobutyric acid. It enhances GABA-stimulated chloride flux, resulting in anxiolysis, sedation and anaesthesia.[55]

In *Kojiki*, the verb "kamu (醸む)" is used to mean "brew". Many believe that the word is etymologically associated with "kamu" (噛む: "to chew"), as one of the earliest forms of Japanese sake is *Kuchikamizake* ("mouth-chewed sake"), which was produced through the saccharification of cereals by chewing before fermentation.[56] Maidens were often responsible for chewing *Kuchikamizake* for religious rituals. Using raw rice and steamed rice, Yamashita demonstrated the production of *Kuchikamizake*, which contained

approximately one to six per cent ethanol.[57] Further, α-amylase in saliva converted starch into sugar, and *Saccharomyces* species from raw rice and *Candida* species from saliva in the case of steamed rice were mainly responsible for alcoholic fermentation. Lactic acid bacteria, including *Lactobacillus salivarius*, *Streptotoccus* species and *Leuconostoc* species from saliva, were also present in lactic acid fermentation.

Deaths in the *Kamitsumaki* of *Kojiki*

Table 1 describes nine deaths in the *Kamitsumaki* of *Kojiki*. Excluding the cases of Yamata-no-orochi and Nakime, which were animal deities, and that of Ame-no-waka-hiko, whose death likely resulted from his own sin of shooting an arrow against heaven, one case was due to infection, and the remaining five cases were due to intentional homicide. The perpetrators were males in all the homicide cases; among the victims were one child, two women, and the remainder were males.

In the Japanese myths in *Kojiki*, violence is clearly predominantly associated with men. Even in today's world, the vast majority of homicide perpetrators are male. According to the *Global Study on Homicide 2013*, approximately ninety-five per cent of perpetrators at the global level are male.[58] What is noteworthy is the proportion of intimate partner/family-related homicides in the *Kamitsumaki*: all of the cases are family member-inflicted homicides. The average rate of intimate partner/family-related homicide is reported to be relatively stable, in contrast with the rates of other forms of homicide, which vary from year to year. It is likely that interpersonal/family-related homicide was common in early Japan. As described earlier, Hata-orime's death likely represents Susa-no-o's violence against Ama-terasu, rather than accidental death. Violence against women by family members and intimate partners remains a huge societal issue in modern societies. In 2012, approximately forty-seven per cent of female homicide victims were killed by their family members or intimate partners, compared with six per cent for male homicide victims. Izanagi beheads his child, who had caused Izanami's sickness in the process of his birth. Studies show that children face the highest risk of homicide by parents (in a study, approximately 56.5% of child homicides were by parents).[59] Studies on skeletons from the Jomon and Yayoi periods indicate that beheading was rare during the Jomon period, but became a method of homicide during the Yayoi period, with the introduction of metallurgy.[60,61]

Table 1 Deaths described in the *Kamitsumaki* of *Kojiki*

	Deceased	The cause of death
1	Izanami	Suspected puerperal fever
2	Kagu-tsuchi-no-kami	Beheading by Izanagi
3	Hata-orime (maiden)	Vaginal penetration by a shuttle, suspected sexual assault by Susa-no-o
4	O-ge-tsu-hime-no-kami	Killed by Susa-no-o (method unknown but likely cutting/piercing by his sword)
5	Yamata-no-orochi	Cutting/piercing by Susa-no-o
6	O-namuji-no-kami	Burn injury (the use of heated stone by his brothers)
7	O-namuji-no-kami	Crush injury, killed by his brothers
8	Nakime (pheasant)	Shot with an arrow by Ame-no-waka-hiko
9	Ame-no-waka-hiko	Hit by an arrow he shot to the heavens (thrown back by Taka-ki-no-kami)

Medications used in the *Kamitsumaki* of *Kojiki*

Human history is also a history of human fighting against diseases. Humans have used various natural products to fight against illnesses since the prehistoric era. A recent research indicated that Neanderthals might have self-medicated dental abscess with the natural antibiotic producing *Penicillium* from moulded herbaceous material.[62] To this date, many traditional medicines have been instrumental in the development of modern medications. Such examples include aspirin and anti-malarial drugs like artemisinin and quinine.[63]

The first description of medical treatment in the Japanese literature is in the well-known myth of *Inaba no shirousagi* – the white rabbit of Inaba. In the tale, a rabbit deceives a crocodile in crossing the ocean from the island of Oki to the cape of Keta but it is wounded by the crocodile. O-namuji-no-kami (another name for O-kuni-nushi-no-kami) then provides instructions on how to treat the wound with the pollen from *kama* (*Typha*). The myth illustrates that, in the past, medical knowledge and skills were deemed important attributes of the head of the community.[28] The pollen from *kama* (*Typha*) has been used as a traditional medicine, especially for wound healing.[4] The pollen from the *Typha* species contains chemicals, including flavonoids, sterols and long-chain hydrocarbons. Recent studies on the pharmacologic effects of *Pollen Typhae* have shown that the pollen extracts possess hemostatic,[64] anti-oxidant and anti-inflammatory properties.[65] A study by Gescher also indicated that *Typha latifolia* fruit polysaccharides stimulate keratinocyte proliferation and early differentiation, supporting the use of the plant for wound healing.[66] In addition to the beneficial effects of the pollen of the *Typha* species, the tale also describes the harmful effects of seawater. Seawater is a nonsterile, hypertonic solution with alkaline pH, and its temperature is lower than that of the human body. A study assessing the effects of seawater immersion on the skin of hairless mice showed that seawater induced time-dependent apoptosis in the epidermis.[67] Seawater has also been found to aggravate inflammatory response, delay wound healing and aggravate endothelial dysfunction after burn injury.

Another folklore remedy described in the account of O-namuji-no-kami is the use of shaved shells to treat burn injury. His brothers kill him with a large rock heated in fire, but he is later revived with a topical agent – a combination of shaved ark shell and clamshell. Maki reported that, in the past, burned ark shell mixed in breast milk was used in Izumo for burn injuries; the application of powdered clamshell for injury has also been documented in old Chinese medical texts.[36] Traditional and homeopathic remedies from molluscs have been used worldwide throughout history. Some studies have evaluated the effects of molluscs on wound healing, and the abalone shell, *Haliotis diversicolor*, has been shown to have anti-inflammatory and burn injury wound-healing properties.[68] Another study showed that amino acids from two molluscs, *Mytilus galloprovincialis* and *Rapana venosa*, accelerated wound healing.[69]

Ninigi-no-mikoto and Ko-no-hana-no-saku-ya-bime

After Ninigi-no-mikoto, the grandson of Ama-terasu, descends from heaven, he marries Ko-no-hana-no-saku-ya-bime. Later, when she tells Ninigi-no-mikoto that she is pregnant, he questions whether the child is actually his:

Then he said:

"Can Saku-ya-bime have become pregnant after only one night? This is not my child; surely it must be the child of an earthly deity".

Then she replied:

"If the child I bear be the child of an earthly deity, then it shall not be born safely; if it be the child of the heavenly deities, then it shall be safe".

Then she built a palace many yards long without a door; entering into this palace, she spread clay to close it up; and when she was about to deliver the child, she set fire to the palace [then] gave birth.

Ninigi-no-mikoto's statement shows that it was considered highly unusual to become pregnant after one night of sexual intercourse. According to a landmark study on the timing of sexual intercourse on the probability of contraception, even with daily intercourse during the six-day fertile period (five days before and the day of ovulation), the probability of contraception leading to a successful pregnancy is estimated to be twenty-five per cent,[70] dropping even lower in the absence of medical knowledge on ovulation and conception.

As with Saku-ya-bime, the presence of fire at the time of delivery is also described when Empress Sao-bime gives birth to her son. In some parts of Japan, including southern Kyushu and Okinawa, there was a custom to keep fire in or around the parturition huts to dispel evil spirits.[39] Keeping fire around the delivery and postpartum is still customary in some cultures.[71] The lighting of fire in proximity to the delivery room has a few benefits from a medical standpoint. First, it prevents maternal and neonatal hypothermia, which is associated with increased risk of neonatal death, especially in pre-term infants.[72] Second, fire can be used for sterilisation of tools or objects used for delivery. In *Nihon shoki*, it is told that a bamboo knife was used to cut the umbilical cord when Saku-ya-bime delivered her children. In some cultures in developing countries, a bamboo knife heated over an open fire is still used to cut the umbilical cord. The use of sterile tools to cut the umbilical cord is crucial for preventing neonatal infections.[73]

In *Kojiki*, there are multiple notions about the custom of childbirth in parturition huts. The practice of delivery in the parturition hut, which is present in many cultures to this date, is often linked to the concept of pollution. However, some scholars argue that childbirth itself was not associated with pollution in Japan until later, as there are no obvious implications of pollution in the description in *Kojiki*, and it was not until the tenth century that the Japanese ritual authority officially classified menstruation and childbirth as *kegare*.[74] In *Kojiki*, it describes how a parturition hut was built by the edge of the beach when Toyo-tama-bime delivered her child. In early Japan, *ubuya*, or parturition huts, were often built near the ocean or away from human habitat.[11] It is possible that the practice of *ubuya* helped decrease the incidence of maternal and neonatal tetanus. Tetanus has been known to humans since ancient times and was an important cause of neonatal mortality until recently in human history. *Clostridium tetani* is an obligately anaerobic bacillus which can form hardy spores.[75] The spores are resistant to heat and chemicals, and their destruction requires autoclaving or prolonged exposure to iodine, hydrogen peroxide, formalin or glutaraldehyde, which were not available in the past. *C. tetani* is often isolated from fertile soil rich in organic matter and can be isolated from human and animal feces. In studies on the distribution of *C. tetani* in Japan, *C. tetani* was isolated from 18.6 to 51% of examined soils.[76] Beach sand or soils of uninhabited land are likely to have fewer *C. tetani* spores, if not contaminated with animal or human feces.

Conclusion

To my knowledge, this paper is the first attempt at comprehensively evaluating, from a medical perspective, descriptions of the myths in the *Kamitsumaki* of *Kojiki*. The myths in this oldest extant Japanese book have received little attention from medical historians and scholars in the medical field, despite intense analyses by experts in other fields. My evaluation has revealed that the *Kamitsumaki* of *Kojiki* contains a wealth of narratives that relate to a broad range of medical disciplines, including obstetrics and gynecology, infectious diseases, concepts of diseases and death, rudimentary statistics, forensic medicine, psychiatry, toxicology and medical therapeutics, providing us with insights into the medical practices and understanding of medical phenomena in early Japan. My review also showed that many of the medical narratives and practices described in *Kojiki* have scientific rationales. The richness of its content makes this book an indispensable resource for research on medical history in Japan.

Numerous interpretations exist of the myths in *Kojiki*. The space did not allow, nor was it the scope of this paper, to perform an exhaustive review and comparison of the existing interpretations. Given limited historical and ethnological records prior to *Kojiki*, my interpretations, like many others, remain conjectural, but my analysis of the *Kamitsumaki* shows that the mythology in *Kojiki* deserves much more consideration and research from a medical perspective.

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古事記の神話――医学的視点から

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要旨：古事記は日本に現存する最古の文書である．日本の神話を記した上巻は，比較神話学，言語学，文学など，様々な分野において研究の蓄積が進んでいる．しかし，医学者による研究は少なく，医学的観点からの包括的な評価はされていない．本稿では，上巻の神話について医学的考察を加え，新しい解釈を提案するとともに，日本神話には，幅広い医学専門領域にまたがる記述が含まれており，上巻が，古代における日本人の医学的行為，および医学的事象に対する理解について知る手掛かりとなることを報告する．また，記述の中には，現代医学の視点から見ても合理的なものも存在する．古事記は，日本医史の研究において，欠かすことのできない資料である．

キーワード：医史，古事記，日本神話，穢れ，産屋