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Association of taurodontism with hypodontia: a controlled study

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Abstract

Although taurodontism has been reported in many syndromes which also feature hypodontia, there have been no previous investigations on the prevalence of taurodontism in patients with hypodontia. Using a novel biometric method for the assessment of taurodontism, we found that 34.8% of 66 patients with hypodontia had at least one mandibular first permanent molar which showed taurodontism compared to only 7.5% of a control group without hypodontia. The trait may be seen both unilaterally and bilaterally and is most frequently seen in patients with multiple missing teeth. The results indicate that clinicians should be alerted to the possibility of taurodontism with its accompanying clinical difficulties in patients with hypodontia.

Introduction

The term taurodontism was first used by Keith in 1913 to describe the molars of Neanderthal human fossils which "had a tendency for the body of the tooth to enlarge at the expense of the roots." This trait, which is of significance to dental clinicians, is also of interest to anthropologists in the determination of the evolution of man (Shaw 1928; Jorgenson 1982).

Taurodontism has been reported as an isolated trait in many case reports (Lunt 1954; Album 1958; Mangion 1962; Hamner et al. 1964; Metro 1965; Regattieri and Llewellyn 1972; Durr et al. 1980; Seow et al. 1985) which may have a familial tendency. In addition, taurodontism has been documented as a manifestation of multiple-system malformation syndromes, including the tricho-dento-osseous (TDO) syndrome (Lichtenstein et al. 1972), Kleinfelter syndrome (Stewart 1974), otodental dysplasia (Levin et al. 1975), ectodermal dysplasia (Stevnick et al. 1972), and Down syndrome (Jaspers 1981).

However, although missing teeth may be an associated feature in many of the cases of taurodontism cited in the literature, there have been no previous studies investigating the prevalence of taurodontism in hypodontia in general. As an ectodermal origin has been suggested for both taurodontism (Jorgenson 1982; Hamner et al. 1964) as well as hypodontia (Barjian 1960), it is likely that these two traits may be associated. Further support of this concept is the fact that taurodontism also may be observed in amelogenesis imperfecta (Witkop and Sauk 1971), a defect of ectodermal origin. In this study we investigated the prevalence of taurodontism in a group of children with hypodontia compared to a control group. To establish the diagnosis of taurodontism objectivity, a novel biometric technique was employed.

Materials and methods

Patients with hypodontia

Random screening of 1032 patient records which had panoramic radiographs from the pediatric dental clinic at the University of Queensland Dental School revealed that 66 patients (6.4%) had agenesis of at least one tooth. There were 37 males and 29 females, and their mean age at the time of radiography was 11.08 ± 2.9 years (range 5-19 years). All the patients were Caucasian and had hypodontia as an isolated trait, and did not suffer these defects as part of an overall syndrome.

Control patients

For every patient with hypodontia, a control was selected who matched the study case for both gender and the age at which the panoramic radiograph was taken. All control patients were shown to have a full permanent dentition from the radiographs. In addition, they did not suffer from any defects which may be features of medical syndromes.

Selection of molar tooth for measurement

The mandibular first permanent molar was selected as the tooth for analysis for several reasons. First, the first molar is considered the most stable tooth of the series; hence, any change in its morphology may indicate a true change of the molar series. In particular, the cuneiform single-rooted molar which is not considered a form of taurodontism (Blumberg et al. 1971) is rarely seen in the first molar, thus eliminating possible errors from misdiagnosis. Second, the entire outline of this tooth usually is evident clearly on the panoramic radiograph in contrast to the maxillary molars where the root apices usually are obscured by the zygomatic bone; hence, lengths of the roots are easily determined. Finally, this first permanent molar is usually the only fully developed molar in the age group under study.

Tooth measurements

The outline of mandibular first permanent molar teeth first was traced from the panoramic radiograph onto transparent paper from which measurements were taken. The parts of each tooth comprising the crown, body, and root were identified using the following definitions: Crown (C) - from the deepest part of occlusal surface to the cementoenamel junction (CEJ); Body (B)—from the CEJ to the root furcation; Root (R) - from the root furcation to the apices (Keith 1913; Shaw 1928; Mena 1971). Figure 1 shows these anatomical divisions on a taurodontic molar.

The lengths of the crown plus body (CB) as well as the root (R) were measured as shown in Fig 1. The CB of the tooth was determined by drawing an occlusal line through the deepest pit which is parallel to another line joining the cusp tips (Fig l). The length was determined along a vertical axis drawn at right angles to the occlusal line measured from the deepest pit to the furcation. Similarly, the length R was determined along the same vertical axis from the furcation to the root apex.

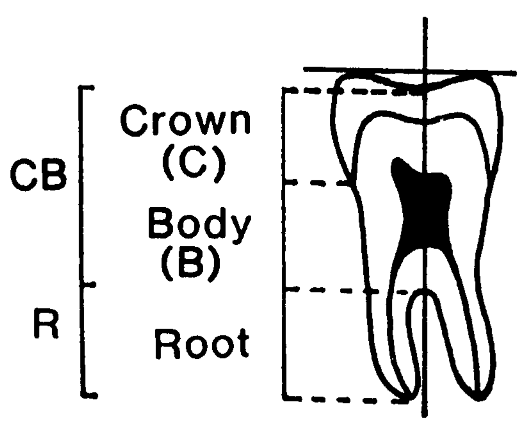

Fig 1. Measurements of crown and root lengths on a mandibular first permanent molar. The crown-body (CB) length was determined by drawing an occlusal line through the deepest pit which is parallel to another line joining the cusp tips. The length was determined along a vertical axis drawn at right angles to the occlusal line measured from the deepest pit to the furcation. *Similarly, the root (R) length was determined along the same* vertical axis from the furcation to the root apex.

Validation of method

As panoramic radiographs may be associated with distortions (Pilo 1987; Balis 1981), we compared the accuracy of the images of mandibular first permanent molars on the panoramic radiographs with the images of the same teeth on periapical radiographs taken with the parallel long-cone technique. The radiographs of twenty patients (11 females, 9 males) who were not part of the study population were used for analysis. All patients had a panoramic radiograph taken at about the same time as a long-cone periapical radiograph of a mandibular first permanent molar. As the latter technique is associated with minimal distortion, comparison of CB:R ratios in the mandibular first molar between the two techniques may determine possible discrepancies due to distortion on the panoramic radiographs.

The results (Table 1) showed that the mean difference in CB:R ratio in the mandibular first molar between the two techniques was not statistically significant ($P > 0.1$), indicating that for this tooth

Table 1. Comparison of Crown-Body to Root Ratios (CB:R) using Panoramic (PAN) vs Periapical (PA) Long-Cone Techniques

Patient No.	*CB:R of Mandibular First Permanent Molar* Panoramic* (PAN)	Parallel Technique Periapical (PA)	*Difference in CB:R (PAN Minus PA)*
1	0.76	0.77	−0.01
2	1.05	1.10	−0.05
3	1.26	1.29	−0.03
4	0.93	1.00	−0.07
5	0.95	1.00	−0.05
6	1.04	1.05	−0.01
7	0.75	0.88	−0.13
8	0.81	0.95	−0.14
9	1.00	1.00	0.00
10	0.91	0.94	−0.03
11	0.94	0.95	−0.01
12	1.00	1.00	0.00
13	1.27	1.22	+0.05
14	0.79	0.82	−0.03
15	0.93	0.90	+0.03
16	1.09	1.03	+0.06
17	0.74	0.74	0.00
18	0.79	0.82	−0.03
19	0.93	0.90	−0.03
20	1.09	1.03	+0.06
Mean ± SD	0.95 ± 0.15	0.97 ± 0.13	−0.02 ± 0.06

The mean difference between the two techniques is not statistically significant ($P > 0.1$)

* The panoramic technique used in this study is described in the text.

selected, the panoramic radiograph is closely equivalent to the long-cone periapical radiograph for the diagnosis of taurodontism using our biometric method.

Statistical analysis

The Student's t-test and the X^2 test as appropriate, were used for statistical analysis of the data.

Results

Prevalence of taurodontism in hypodontia and control groups

Table 2 shows the prevalence of taurodontism of the mandibular first permanent molar in the hypodontia group compared with the control group. As shown in the table, taurodontism was diagnosed in 34.8% of hypodontia patients compared with only 7.5% of control, the difference being statistically significant ($P < 0.001$).

The prevalence of taurodontism was further analyzed according to sex (Table 3). As shown in the table, there were no significant differences in prevalence between the sexes in both the hypodontia and control groups.

Table 2. Prevalence of Taurodontism in Patients with Hypodontia Compared to Control

	No. of patients	
Taurodontism of 1st Permanent Molar	*Hypodontia (N = 66)*	*Control (N = 66)*
Present	23 (34.8%)*	5 (7.5%)
Absent	43 (65.2%)	62 (92.5%)

* $X^2 = 14.99$, df = 1, $P < 0.001$

Table 3. Prevalence of Taurodontism According to Sex

	Taurodontism Present	
	Hypodontia	*Control*
Males (N = 37)	13 (35.1%)*	3 (8.1%)
Females (N = 29)	10 (34.5%)	2 (6.9%)

Figures in parentheses represent percentages of the total numbers of males and females in each group.

Prevalence of various classes of taurodontism

For the diagnosis of a normal or cynodont tooth (Keith 1913), a CB:R ratio of 1:1 is reasonable, as it has been suggested that the length of the roots of a normal molar is at least equal to the crown-body length (Keith 1913). This concept was confirmed in preliminary measurements of molars subjectively classified as normal in our preliminary investigations. However, to exclude misdiagnosis due to slight inaccuracies of measurements and radiographic distortions, a CB:R ratio of slightly less than 1:1 (i.e., < 1:1.1) was considered to be within normal limits.

According to Shaw (1928), taurodontism occurs in varying degrees that may be classified in increasing order of severity as hypotaurodontism, mesotaurodontism, and hypertaurodontism. As these distinctions usually were determined subjectively previously, we attempted an objective classification based on the CB:R ratio.

Mandibular first permanent molars first were classified subjectively into these 3 groups by visual examination of panoramic radiographs. Mean CB:R ratios were obtained for each putative group of taurodontism. From these preliminary measurements, it was determined that CB:R ratios of the range 1.10 – 1.29 be classified as the hypotaurodont group, those in the range 1.30 – 2.00 as the mesotaurodont group, and those > 2.00 as the hypertaurodont group. Figure 2 shows a diagrammatic representation of these classes of taurodontism.

The prevalence of the 3 groups of taurodontism based on the above classification is shown in Table 4 (next page). As seen from Table 4, 94.8% of mandibular first permanent molars were classified as normal (cynodont) in the control group compared to only 70.5% in the hypodontia group ($P < 0.001$). In the latter group, 18.9% of all the teeth analyzed were classified as hypotaurodont, 9.8% as mesotaurodont, and 0.8% as hypertaurodont. In contrast, in the control group, only 4.5% of all the teeth analyzed were classified as hypotaurodont, 0.7% as mesotaurodont and no teeth showed hypertaurodontism. These differences in the prevalence of different classes of taurodontism between the 2 groups are statistically significant ($P < 0.001$).

Type of hypodontia associated with taurodontism

It is of interest to determine if taurodontism is associated with certain patterns of hypodontia. Table 5 (next page) shows the different types of hypodontia showing taurodontism in the mandibular first permanent molars. As seen from the table, 56.5% of patients with taurodontism had multiple missing teeth, 30.4% had missing premolars, 8.7% had missing lateral incisors and 4.3% had both lateral incisors and

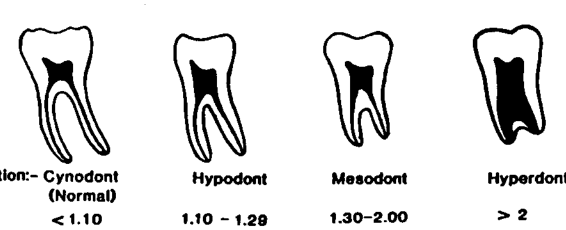

Fig 2. Diagrammatic representation of the three classes of taurodontism as proposed by Shaw (1928).

TABLE 4. Prevalence of Taurodontic Mandibular First Permanent Molars in Hypodontia and Control Groups

Type of Taurodontism	Crown & Body : Root (CB:R) Ratio	No. of Lower First Permanent Molars Hypodontia (N = 132)	Control (N = 132)	P Value
Cynodont (Normal)	< 1.10	93 (70.5%)	125 (94.8%)	$P < 0.001$[1]
Hypotaurodont	1.10 – 1.29	25 (18.9%)	6 (4.5%)	$P < 0.001$[2]
Mesotaurodont	1.30 – 2.00	13 (9.8%)	1 (0.8%)	$P < 0.001$[3]
Hypertaurodont	> 2.00	1 (0.8%)	0	N.S.

[1] $X^2 = 27.59$, df = 1.
[2] $X^2 = 13.51$, df = 1.
[3] $X^2 = 11.04$, df = 1.

TABLE 5. Type of Hypodontia Associated with Taurodontism

Type of hypodontia (Mandibular + Maxillary)	No. of Patients Showing Taurodontism in Mandibular First Molar (N = 23)
Isolated missing teeth (N = 46)	
Central incisor (N = 1)	0
Lateral incisors (N = 20)	2 (8.7%)
Premolars (N = 21)	7 (30.4%)
Lateral incisors and premolars (N = 4)	1 (4.3%)
Multiple missing teeth* (N = 20)	13 (56.5%)

* The number of missing teeth varied from 6 to 22.
The difference in the results between the group of patients showing isolated hypodontia and the group with multiple missing teeth is statistically significant, $X^2 = 11.3$, df = 1, $P < 0.001$.

premolars missing. The differences in the results between the group of patients showing isolated hypodontia and the group with multiple missing teeth is statistically significant ($P < 0.001$).

Occurrence of unilateral and bilateral taurodontism

The occurrence taurodontism in mandibular first permanent molars in unilateral and bilateral cases is analyzed in Table 6. As shown in the table, nearly half (47.8%) of the cases of taurodontism occurred bilaterally, and the other half unilaterally. In the latter cases, there was no significant preference of left (30.4%) or right sides (21.7%).

Discussion

Since the first observation of cylindrical or prismatic teeth in prehistoric hominids (Keith 1913) and in modern man (Pickerill 1909), taurodontism has been of great interest to anthropologists, being thought by some as an atavistic trait (Hrdlicka 1914) and by others as excluding Neanderthal man from the direct ancestral line of modern man (Boule and Vellois 1957).

Shaw (1928) classified taurodontism into hyper-, meso-, and hypo- types based on subjective criteria, but there have been some attempts to define the trait objectively. Keene (1966) proposed a "taurodontism index" which compared the vertical height of the pulp chamber to the vertical height of the tooth portion containing the pulp to define the different classes of taurodontism biometrically. However, as pulp chamber size may alter due to environmental changes and aging, Keene's technique was not considered useful (Stevnick et al. 1972). Blumberg et al. (1971) improved on Keene's technique by using metrical attributes which were thought to be stable and not influenced by caries, sex, or age, but subjective criteria were still employed for the development of their discriminant analysis and diagnosis of taurodontic teeth (Jaspers and Witkop 1980).

In the present study we developed a novel method of diagnosis of taurodontism in molars based on radiographic measurements of crown and body height to root length ratios. Although crown height may decrease with attrition, the method is simple to use and is suitable for young patients in whom there is minimal wear of the occlusal surface. In addition, the panoramic radiograph used in our method often is included as part of routine clinical assessments in pediatric dentistry.

Using this method of analysis, we found that 34.8% of patients with hypodontia also showed taurodontism of at least one mandibular first permanent molar compared with only 7.5% of control. Of great interest is the finding that in nearly half of the cases taurodontism was observed unilaterally, in contrast to previous findings (Shifman and Chanannel 1978). Figure 3 (next page) illustrates a typical patient exhibiting taurodontic molars in association with missing teeth. There was no sex preference, and the trait may be observed both unilaterally and bilaterally. In addition, the severest

TABLE 6. Occurrence of Unilateral and Bilateral Taurodontism in Mandibular First Molars

	Occurrence of Taurodontism Unilateral Left	Unilateral Right	Bilateral
	7	5	11
Percentage	30.4%	21.7%	47.8%

The above results are not statistically significant, $P > 0.01$.

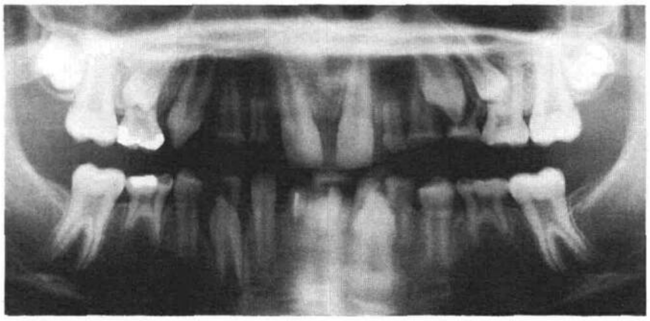

Fig 3. Panoramic radiograph of a typical patient in the study depicting the association of missing teeth with taurodontic molars.

form of hypodontia with multiple missing teeth is most often associated with taurodontism. In our study, the prevalence figure in the control group is within the range reported by other investigators using different methods of measurements and analysis. For example, an incidence of 6.3% was reported in British school children (Holt and Brook 1979), and Shifman and Chanannel (1978) mentioned that 5.6% of young Israeli adults aged 20 to 30 showed taurodontism. However, lower figures were observed by Keene (1966) who found the trait in 3.4% of navy recruits, and Blumberg who reported a 2.5% prevalence in his study of Caucasian patients.

To the authors' knowledge, there has been no previous study showing association of taurodontism in a large group of patients with hypodontia, even though taurodontism has been reported in many syndromes that also feature hypodontia (Seow et al. 1985; Lichtenstein et al. 1972; Levin et al. 1975; Stevnick et al. 1972). As many of these syndromes involve ectodermal defects, it is possible that hypodontia and taurodontism may both be manifestations of an ectodermal defect. In addition, taurodontism also is observed in some types of amelogenesis imperfecta (Winter et al. 1969), an aberration of ectodermal origin. Our study showing the association of taurodontism with hypodontia thus further supports the concept that taurodontism probably results from an alteration in Hertwig's epithelial root sheath (Hamner et al. 1964) which is an ectodermal derivative.

Several clinical complications may result from the abnormal morphology of a taurodontic tooth. In endodontic therapy, the extensive length of the pulp chamber may create difficulties in location of root canals and subsequent problems in cleaning and obturation. These difficulties are compounded by the presence of pulp stores and unusual apical root canal systems which often accompany taurodontism (Shaw 1988).

In fixed prosthesis therapy it is reasonable to suggest that a taurodontic molar may not be considered an adequate abutment tooth since its smaller surface area may be less resistant to lateral displacing forces compared to cynodont teeth. By the same reasoning, it may be suggested that exodontia of taurodontic molars should be easier compared to cynodont teeth; however, difficulties have been reported (Mangion 1962).

It has been suggested that taurodontism may actually be advantageous from a periodontal aspect. This is due to the more apical location of the furcation which is thus less susceptible to periodontal disease.

In conclusion, the results of the present study showing the association of taurodontism with hypodontia indicates that clinicians should be alerted to the possibility of this unusual dental morphology in all patients with missing teeth.

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Album MM: Taurodontia in deciduous first molars. J Am Dent Assoc 56:562, 1958.

Balis S: Error and accuracy rates of panoramic radiography as a screening method for mass surveying of children. J Publ Health Dent 41:220-34, 1981.

Barjian H: The effect of early dental treatment of anhidrotic ectodermal dysplasia. J Am Dent Assoc 61:555-69, 1960.

Blumberg JE, Hylander WL, Goepp RA: Taurodontism : a biometric study. Am J Phys Anthropol 34:243-56, 1971.

Boule M, Vallois HV: "Fossil Man." London: Thames and Hudson, 1957.

Durr DP, Campos CA, Ayers CS: Clinical significance of taurodontism. J Am Dent Assoc 100:378-81, 1980.

Hamner JE, Witkop CJ, Metro PS: Taurodontism. Oral Surg 18:409-18, 1964.

Holt RD, Brook AH: Taurodontism: A criterion of diagnosis and its prevalence in mandibular first permanent molars in a sample of 1115 British school children. Int Assoc Dent Child 10:41-47, 1979.

Hrdlicka A: The most ancient remains of man. Rep Smithsonian Inst 2300, 1914.

Jaspers MT: Taurodontism in the Down syndrome. Oral Surg 51:632-36, 1981.

Jaspers MT, Witkop CJ: Taurodontism, an isolated trait associated with syndromes and X-chromosomal aneuploidy. Am J Hum Genet 32:396-413, 1980.

Jorgenson RJ: The conditions manifesting taurodontism. Am J Med Genet 11:435-42, 1982.

Keene HJ: A morphologic and biometric study of taurodontism in a contemporary population. Am J Phys Anthropol 25:208-9, 1966.

Keith A: Problems relating to the teeth of the earlier forms of prehistoric man. Proc Odontol Sec Roy Soc Med 6:103-24, 1913.

Levin LS, Jorgenson RJ, Cook RA: Otodental dysplasia: A "new" ectodermal dysplasia. Clin Genet 8:136-44, 1975.

Lichtenstein J, Warson R, Jorgenson R, Dorst JP, McKusick VA: The tricho-dento-osseus (TDO) syndrome. Am J Hum Genet 24:569-82, 1972.

Lunt D: A case of taurodontism in a modern European molar. Dent Rec 74:307-12, 1954.

Mangion JJ: Two cases of taurodontism in modern human jaws. Br Dent J 113:309-12, 1962.

Mena CA: Taurodontism. Oral Surg 32:812-23, 1971.

Metro PS: Taurodontism: A dental rarity in modern man. Oral Surg 20:236-37, 1965.

Ogden GR: The significance of taurodontism in the dental surgery. Dent Update 15:32-34, 1988.

Pickerill HP: Radicular aberrations: bilateral radicular dentomata. Proc R Soc Med 2:150-52, 1909.

Pilo R: Diagnosis of developmental dental anomalies using panoramic radiographs. ASDC J Dent Child 54:267-72, 1987.

Regattieri LR, Llewellyn JS: Taurodontism. Oral Surg 34:691, 1972.

Sauk JJ, Delaney JR: Taurodontism, diminished root formation and microcephalic dwarfism. Oral Surg 36:231-35, 1973.

Seow WK, Brown JP, Romaniuk K: The Nance-Horan syndrome of dental anomalies, congenital cataracts, microphthalmia and anteverted pinna : case report. Pediatr Dent 7:307-11, 1985.

Shaw GR: The significance of taurodontism in dental surgery. Dent Update 1:32-34, 1988.

Shaw JC: Taurodont teeth in South African races. J Anat 62:476-99, 1928.

Shifman A, Chanannel I: Prevalence of taurodontism found in radiographic dental examinations of 1200 young adult Israel patients. Community Dent Oral Epidemiol 6:200-203, 1978.

Stevnick A, Zachrisson BU, Svatun B: Taurodontism and concomitant hypodontia in siblings. Oral Surg 33:841-45, 1972.

Stewart RE: Taurodontism in X-chromosome aneuploid syndromes. Clin Genet 6:341-44, 1974.

Winter GB, Lee KW, Johnson NW: Hereditary amelogenesis imperfecta, a rare autosomal dominant type. Br Dent J 127:157-64, 1969.

Witkop CJ, Sauk JJ: In Dental and oral manifestations of hereditary disease. New York: American Academy of Oral Pathology, 1971.

EPA waste regulations will cover dentists

Generators of small amounts of potentially infectious medical wastes will be required to meet many of the waste disposal rules the Environmental Protection Agency is drafting under new legislation.

Dentists and other generators of less than 50 pounds of waste a month will have to segregate, package, label and keep log books for their waste disposal, according to an EPA spokesman. Rules may allow for monthly fluctuations above and below 50 pounds as long as annual limits are not exceeded. EPA may also allow an exemption for private practitioners transporting wastes in their own vehicles.

The Medical Waste Tracking Act of 1988, Public Law 100-582, requires the EPA to set up an experimental waste tracking system by this summer in 10 East Coast and Great Lakes states. New York, New Jersey and Connecticut will probably take part; also expected to join the experiment are Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania and Wisconsin. North Carolina, South Carolina, Florida, Massachusetts, Delaware and American Samoa also express interest in participating.

The EPA will require tracking of five mandated types of wastes specified by Congress—including blood and blood products, needles and other sharps, and human tissues—and may add unused sharps and two other categories to the list. Unused sharps on a beach are considered a physical and aesthetic hazard by the EPA. The law allows EPA to include in the tracking system any waste that poses a threat to health or the environment.