

ORIGINAL ARTICLES

FEVER AND CLINICAL THERMOMETRY: WHAT DO PHYSICIANS AND NURSES REALLY KNOW?

FEBRE E TERMOMETRIA CLÍNICA: O QUE SABEM REALMENTE MÉDICOS E ENFERMEIROS?

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ABSTRACT

Introduction: Fever is a leading cause of Pediatric visits. However, most studies used as reference for fever assessment had a cross-sectional design and were conducted in adults. Different and more precise fever definitions exist within the field of knowledge known as clinical thermometry.

Aims: To assess basic knowledge of health professionals working in Pediatrics regarding fever physiopathology and clinical thermometry.

Material and Methods: A cross-sectional analytical study was performed between February and July 2014 through application of an anonymous closed-end questionnaire to health professionals.

Results: From 426 questionnaires applied, 29% were completed by nurses and 71% by physicians. Within the whole group, 89% did not know how human “normal temperature” was determined, 70% did not recognize the “individual definitions” of fever, 33% acknowledged a “subfebrile” status, 39% did not recognize the most and least accurate anatomical sites for temperature measurement, and 57% did not recognize the dynamic difference between core and peripheral temperatures. Hyperthermia and fever definitions were confounded by 78% of nurses and 56% of physicians.

Conclusions: Most health professionals surveyed had a limited knowledge of fever and clinical thermometry. The traditional oversimplification of this subject can lead to underestimation of true febrile statuses.

Keywords: Clinical thermometry; fever; healthcare professionals; normal temperature

RESUMO

Introdução: A febre é uma das principais causas de consulta pediátrica. Contudo, a maioria dos estudos utilizados como referência para avaliação da febre tiveram um desenho transversal e avaliaram populações adultas. Existem outras definições de febre, mais precisas, que se enquadram numa área de estudo designada por termometria clínica.

Objetivos: Avaliar os conhecimentos básicos dos profissionais de saúde atuantes na área da Pediatria sobre fisiologia da febre e termometria clínica.

Material e Métodos: Estudo analítico, transversal, conduzido entre fevereiro e julho de 2014, efetuado por aplicação de um questionário anonimizado, com perguntas fechadas, a profissionais de saúde.

Resultados: De um total de 426 questionários, 29% foram preenchidos por enfermeiros e 71% por médicos. Considerando o grupo total, 89% desconhecia como a “temperatura normal” em humanos tinha sido determinada, 70% não reconhecia as “definições individuais” de febre, 33% acreditava no estado “subfebril”, 39% não reconhecia os locais anatómicos mais e menos precisos para a medição da temperatura e 57% não reconhecia a diferença dinâmica entre as temperaturas periférica e central. As definições de febre e hipertermia foram confundidas por

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78% dos enfermeiros e 56% dos médicos.

Conclusões: A maioria dos profissionais de saúde que responderam ao questionário evidenciou conhecimentos limitados sobre febre e termometria clínica. A tradicional simplificação do tema pode contribuir para a subestimativa de verdadeiros estados febris.

Palavras-chave: febre; profissionais de saúde; termometria clínica; temperatura normal

INTRODUCTION

Fever is the most frequent cause of Pediatric Emergency Department visits (approximately 20% of cases), accounting for more than 30% of urgent Pediatric private practice consultations.¹⁻⁶ Several studies have investigated caregivers' knowledge of clinical thermometry, fever and its treatment, largely focused on misconceptions regarding the concept of fever phobia.^{5,7-10} Many health professionals have fever phobia and pass it on to caregivers.^{1,7,9-14} This phobia can be justified by their misconceptions about "normal temperature", different fever definitions, and clinical thermometry.^{7,15,16}

A healthy human body regulates its core temperature to values within $\pm 0.2^{\circ}\text{C}$ of the "average" and peripheral temperature narrowly varies between $\pm 1.0^{\circ}\text{C}$ (1.8°F) or $\pm 2.0^{\circ}\text{C}$ (3.6°F) of the average, aside from environmental temperature changes.^{15,17,18}

The various peripheral (or external) body temperatures do not reflect the core temperature and vary according to anatomical site of measurement.^{2,15,17,19}

Fever is difficult to define. The traditional definitions of "normal temperature" originated from cross-sectional populational studies and described temperatures above the 99th or 97.5th percentiles of the population's body temperature.^{2,4,15,18,20-22} The consideration that a single number, currently acknowledged to vary according to measurement site, can represent the thermal status of the entire body is inaccurate.^{18,19,23} Only with an individual-centred definition can the concept of fever take into account the temperature variability within a single person. Thus, one possible fever definition can refer to the temperature above the individual's normal daily variation, depending on the anatomical site of measurement.^{2,18,24-25}

Since most people do not know their normal body temperature and considering that the individual temperature varies $\pm 1.0^{\circ}\text{C}$ (1.8°F) of their own average temperature, the following individual fever definition can be accepted: temperature $\geq 1.0^{\circ}\text{C}$ (1.8°F) of the individual's average temperature on a specific anatomic location.^{2,18}

The subfebrile concept, although widely used in clinical practice, is not mentioned in renowned scientific books.^{26,27} It was probably the result of applying a general population fever definition to a particular individual plus the need to treat patients with low-grade fever.^{18,28,29} Therefore, the traditional fever definitions can lead to misinterpretation of the real condition of many patients with low physiological temperature and thus low-grade fever.

Thermometry, which includes clinical thermometry, is the science that studies body temperature as well as methods and accuracy of anatomic sites for temperature quantification.^{20,30}

If in fever research studies it is mandatory to provide a number to define fever, in clinical evaluation and treatment of a patient with fever it is key to correctly recognize the individual "normal temperature" and to accurately evaluate temperature in the anatomical peripheral site that most accurately reflects his core temperature.^{2,17} Some experts have sought to devise formulas for converting axillary and oral temperatures into rectal temperature.^{15,31} However, the changeable nature of thermoregulation justifies the dynamic and Gaussian differences observed between core and peripheral temperatures.^{2,17,18,22}

The aim of this study was to evaluate physicians' and nurses' knowledge on human "normal temperature", fever, and clinical thermometry.

MATERIAL AND METHODS

A cross-sectional analytical study was conducted between February and July 2014 by application of an anonymous closed-end questionnaire to physicians and nurses. The questionnaire was developed by the authors and initially validated in a small sample (thirty-eight physicians and one nurse), with subsequent modifications if required. The questionnaire was then e-mailed or personally distributed, using a convenience sample. Only questionnaires with more than 90% of questions answered were considered valid.

Three fever definitions were considered: 1) traditional temperature, i.e. above the populations' "normal temperature" at a specific anatomic site (above the 97.5th or 99th percentiles); 2) temperature above the individual "normal temperature" at a specific anatomic site; and 3) temperature 1.0°C (1.8°F) above the individual average temperature at a specific anatomic site.^{2,4,18,23-25}

The 'subfebrile' status was considered an erroneous or non-existing concept.^{18,29} The traditional fever definition for each anatomical evaluation site were adopted: rectal temperature $\geq 38.0^{\circ}\text{C}$ (100.4°F), axillary temperature $\geq 37.4^{\circ}\text{C}$ (99.3°F), tympanic temperature $\geq 37.6^{\circ}\text{C}$ (99.7°F), oral temperature $\geq 37.5^{\circ}\text{C}$ (99.5°F), and temporal temperature $\geq 37.7^{\circ}\text{C}$ (99.9°F).^{2,4,11,18,32,33}

The non-invasive methods for temperature assessment that theoretically better correlate with core temperature are the rectal and tympanic temperatures; rectal was considered the standard and most reliable non-invasive measurement method, while tympanic was considered the least reliable method.^{4,6,17,19,20,22,23,32-35} Within the same individual, rectal temperature was assumed to be the highest and tympanic temperature was assumed to be higher than axillary temperature; rectal temperature was assumed to be, on average, about 1.0°C (1.8°F) above the axillary temperature by electronic thermometers, both in apyrexia and fever, varying between 0.0°C (0.0°F) and 2.0°C (3.6°F) in apyrexia and between 0.0°C

(0.0°F) and 3.0°C (5.4°F) in fever, as they depend on skin dynamic thermoregulation mechanisms.^{2,4,17,18,22,23,28,35}

Hyperthermia was defined as exogenous warming beyond thermoregulatory center control, different from the thermoregulatory center-controlled endogenous heating that characterizes fever.^{2,6,15}

Statistical analysis was performed with SPSS® version 22, using χ^2 test for large groups and Fisher's exact test for small groups, considering a p-value <0.05 as statistically significant. Two group samples were compared: physicians versus nurses.

RESULTS

From 723 questionnaires delivered, 426 (58.9%) with more than

90% of questions answered were returned: 125 (29.3%) from nurses and 301 (70.7%) from physicians. Fifty-six percent of nurses worked in the Pediatric department compared to 54.2% of Pediatric physicians.

In total, 89.4% of responders did not know how human "normal temperature" was determined; only 11.9% were aware of the three definitions of fever; only 36.3% accurately defined core temperature; and 73.5% acknowledged subfebrile body temperatures. Approximately one third of health professionals were not aware of the most and least reliable anatomical sites for temperature measurement (33.4% and 38.6%, respectively); 56.5% ignored the dynamic difference between rectal and axillary temperature and 62.4% mistook hyperthermia for fever (**Table 1**).

Table 1 - Participants' answers to the closed-end questionnaire

1) Regarding population studies on human normal temperature (select the right answer?)	All respondents (n=426)	%
All cross-sectional studies [#]	84	10.6
Cross-sectional and longitudinal studies	7	17.6
All longitudinal studies	218	2.3
It is not relevant	38	10.6
I don't know	77	58.9
2) Regarding studies on human normal temperature, which do we use daily? (select the right answer)	All respondents (n=424)	%
Average individual normal temperature	128	19.8
Maximum individual normal temperature	78	1.6
Average population normal temperature	50	51.4
Maximum population normal temperature [#]	63	9.0
I don't know	102	18.2
3) How many fever definitions do you know? (select the right answer)	All respondents (n=421)	%
One	56	30.4
Two	59	18.5
Three [#]	135	11.9
It is not relevant	137	15.0
I don't know	35	24.2
4) About fever definitions (select the wrong answer)	All respondents (n=422)	%
Higher than normal for the individual, depending on the anatomic site of evaluation	19	13.3
More than 1°C above the average individual temperature, depending on the anatomic site of evaluation	90	14.0
Equal or higher than 37.4°C (99.3°F) axillary temperature	189	32.0
Equal or higher than 38.0°C (100.4°F) axillary temperature [#]	113	32.4
I don't know	15	8.3
5) About subfebrile definition (select the right answer)	All respondents (n=426)	%
Precedes fever	103	4.5
Temperatures between 37.1–37.5°C (98.8–99.5°F)	32	21.1
Temperatures between 37.5–38.0°C (99.5–100.4°F)	76	44.4
Does not exist [#]	78	26.5
I don't know	136	3.5

6) In ambulatory, how can we assess core temperature (select the right answer)	All respondents (n=425)	%
Body temperature	82	24.2
Axillary temperature	7	7.5
Rectal temperature [#]	283	17.9
Rectal or tympanic temperature [#]	1	18.4
I don't know	52	32.0
7) What is the most reliable anatomic site for temperature measurement? (select the right answer)	All respondents (n=425)	%
Axillary	43	19.3
Oral	82	1.7
Rectal [#]	7	66.6
Temporal	258	0.2
Tympanic	30	12.2
8) What is the least reliable anatomic site for temperature measurement? (select the right answer)	All respondents (n=420)	%
Axillary	258	10.2
Oral	113	19.5
Rectal	1	1.7
Temporal [#]	32	61.4
Tympanic	21	7.2
9) Knowing that temperature differs according to anatomic evaluation site (select the right answer)	All respondents (n=425)	%
Axillary < tympanic < rectal [#]	185	60.7
Axillary < tympanic = rectal	70	26.6
Axillary = tympanic = rectal	58	0.2
Axillary = oral < rectal	69	7.5
I don't know	43	5.0
10) About the difference between rectal and axillary temperature: (select the wrong answer)	All respondents (n=425)	%
Varies between 0.5–1.0°C (0.9–1.8°F) [#]	62	43.5
Varies on average ±1.0°C (1.8°F)	39	16.5
Varies between 0–2.0°C (0–3.6°F) in apyrexia	113	13.7
Varies between 0–3.0°C (0–5.4°F) in fever	160	16.2
I don't know	52	10.1
11) Regarding fever, hyperthermia and hyperpyrexia concepts (select the right answer)	All respondents (n=426)	%
Hyperthermia = fever	62	14.5
Hyperpyrexia = hyperthermia	39	9.2
Hyperthermia = endogenous warming	113	26.5
Hyperthermia = exogenous warming [#]	160	37.6
I don't know	52	12.2

Legend: #correct answer

Compared with nurses, physicians were more informed regarding fever definitions and clinical thermometry (**Table 2**). A higher proportion of physicians were familiar with the temperature concept used in studies of “normal temperature” estimation (11.3% versus 3.2% of nurses, $p=0.008$) and an also higher proportion of physicians acknowledged the core temperature definition (46.4% versus 12.0% of nurses, $p<0.001$). Although 65.3% of physicians were not aware of the two “individual fever” definitions, this proportion

was significantly higher for nurses (79.9%). A significantly higher proportion of physicians did not acknowledge a subfebrile status (29.9% versus 18.4%, $p=0.014$) and considered that fever definition varied according to anatomical site of measurement (28.3% versus 17.6%, $p=0.020$). Compared with nurses, more physicians considered rectal temperature as the most reliable (70.3% versus 57.6%, $p=0.008$) and were acquainted with the concept of hyperthermia (43.9% versus 22.4%, $p<0.001$).

Table 2 - Comparison between physicians' and nurses' answers

1) Regarding population studies on human normal temperature (select the right answer?)	Physicians (n=301)	Nurses (n=125)	P
All cross-sectional studies [#]	37 (12.3%)	8 (6.4%)	0.072
Cross-sectional and longitudinal studies	48 (15.9%)	27 (21.6%)	0.337
All longitudinal studies	7 (2.3%)	3 (2.4%)	0.602
It is not relevant	30 (10.0%)	15 (12.0%)	0.534
I don't know	179 (59.5%)	72 (57.6%)	0.721
2) Regarding studies on human normal temperature, which one do you use daily? (select the right answer)	Physicians (n=300)	Nurses (n=124)	P
Average individual normal temperature	44 (14.7%)	40 (32.3%)	<0.001*
Maximum individual normal temperature	5 (1.7%)	2 (1.6%)	0.968
Average population normal temperature	165 (55.0%)	53 (42.7%)	0.022*
Maximum population normal temperature [#]	34 (11.3%)	4 (3.2%)	0.008*
I don't know	52 (17.3%)	25 (20.2%)	0.492
3) How many fever definitions do you know? (select the right answer)	Physicians (n=297)	Nurses (n=124)	P
One	73 (24.6%)	55 (44.4%)	<0.001*
Two	56 (18.9%)	22 (17.7%)	0.789
Three [#]	47 (15.8%)	3 (2.4%)	<0.001*
It is not relevant	47 (15.8%)	16 (12.9%)	0.444
I don't know	74 (24.9%)	28 (22.6%)	0.610
4) About fever definitions (select the wrong answer)	Physicians (n=298)	Nurses (n=124)	P
Higher than normal for the individual, depending on the anatomic site of evaluation	32 (10.7%)	24 (19.3%)	0.017*
More than 1°C above the average individual temperature, depending on the anatomic site of evaluation	47 (15.8%)	12 (9.7%)	0.100
Equal or higher than 37.4°C (99.3°F) axillary temperature	102 (34.2%)	33 (26.6%)	0.127
Equal or higher than 38.0°C (100.4°F) axillary temperature [#]	93 (31.2%)	44 (35.5%)	0.393
I don't know	24 (8.1%)	11 (8.9%)	0.782
5) About subfebrile definition (select the right answer)	Physicians (n=301)	Nurses (n=125)	P
Precedes fever	12 (4.0%)	7 (5.6%)	0.569
Temperatures between 37.1–37.5°C (98.8–99.5°F)	48 (15.9%)	42 (33.6%)	<0.001*
Temperatures between 37.5–38.0°C (99.5–100.4°F)	139 (46.2%)	50 (40.0%)	0.309
Does not exist [#]	90 (29.9%)	23 (18.4%)	0.014*
I don't know	12 (4.0%)	3 (2.4%)	0.312
6) In ambulatory, how can we assess core temperature (select the right answer)	Physicians (n=300)	Nurses (n=125)	P
Body temperature	64 (21.3%)	39 (31.2%)	0.031*
Axillary temperature	15 (5.0%)	17 (13.6%)	0.002*
Rectal temperature [#]	71 (23.7%)	5 (4.0%)	<0.001*
Rectal or tympanic temperature [#]	68 (22.7%)	10 (8.0%)	<0.001*
I don't know	82 (27.3%)	54 (43.2%)	0.001*
7) What is the most reliable anatomic site for temperature measurement? (select the right answer)	Physicians (n=300)	Nurses (n=125)	P
Axillary	46 (15.3%)	36 (28.8%)	0.002*
Oral	6 (2.0%)	1 (0.8%)	0.337
Rectal [#]	211 (70.3%)	72 (57.6%)	0.008*
Temporal	1 (0.3%)	0 (0%)	0.704
Tympanic	36 (12.0%)	16 (12.8%)	0.667

8) What is the least reliable anatomic site for temperature measurement? (select the right answer)	Physicians (n=296)	Nurses (n=124)	P
Axillary	30 (10.2%)	13 (10.5%)	0.931
Oral	51 (17.2%)	31 (25.0%)	0.072
Rectal	5 (1.7%)	2 (1.6%)	0.655
Temporal [#]	186 (63.8%)	72 (58.1%)	0.318
Tympanic	24 (8.1%)	6 (4.8%)	0.229
9) Knowing that temperature differs according to anatomic evaluation site (select the right answer)	Physicians (n=300)	Nurses (n=125)	P
Axillary < tympanic < rectal [#]	173 (57.7%)	85 (68.0%)	0.047*
Axillary < tympanic = rectal	91 (30.3%)	22 (17.6%)	0.007*
Axillary = tympanic = rectal	0 (0%)	1 (0.8%)	0.294
Axillary = oral < rectal	24 (8.0%)	8 (6.4%)	0.569
I don't know	12 (4.0%)	9 (7.2%)	0.165
10) About the difference between rectal and axillary temperature: (select the wrong answer)	Physicians (n=300)	Nurses (n=125)	P
Varies between 0.5–1.0°C (0.9–1.8°F) [#]	137 (45.7%)	48 (38.4%)	0.169
Varies on average ±1.0°C (1.8°F)	51 (17.0%)	19 (15.2%)	0.648
Varies between 0–2.0°C (0–3.6°F) in apyrexia	36 (12.0%)	22 (17.6%)	0.125
Varies between 0–3.0°C (0–5.4°F) in fever	50 (16.7%)	19 (15.2%)	0.709
I don't know	26 (8.7%)	17 (13.6%)	0.124
11) Regarding fever, hyperthermia and hyperpyrexia concepts (select the right answer)	Physicians (n=301)	Nurses (n=125)	P
Hyperthermia = fever	29 (9.6%)	33 (26.4%)	<0.001*
Hyperpyrexia = hyperthermia	18 (6.0%)	21 (16.8%)	0.001*
Hyperthermia = endogenous warming	87 (28.9%)	26 (20.8%)	0.085
Hyperthermia = exogenous warming [#]	132 (43.9%)	28 (22.4%)	<0.001*
I don't know	35 (11.6%)	17 (13.6%)	0.571

Legend: #correct answer; *p<0.05

Comparing physicians working in Pediatrics (residents included) with those working in other clinical departments (namely general practice), the second group was found to acknowledge only one fever definition (33.1% considered only one definition versus 18.1% of those working in Pediatrics, p=0.003; **Table 3**). Additionally, more pediatricians acknowledged the definition of core temperature (54.4% versus 37.3%) and considered that subfebrile temperatures

do not exist (36.2% versus 22.2%, p=0.010) compared with physicians from other specialties.

When comparing pediatricians with their residents, results were similar (**Table 4**) except for the less reliable anatomical site for temperature assessment, with specialists denoting more knowledge than residents.

Table 3 - Comparison between answers of physicians working in Pediatrics (pediatricians/pediatric residents) with other physicians

Legend: #correct answer; *p<0.05	Pediatrics (n=163)	Other physicians(n=134)	P
All cross-sectional studies [#]	26 (15.9%)	10 (7.5%)	0.026*
Cross-sectional and longitudinal studies	20 (12.3%)	28 (20.9%)	0.044*
All longitudinal studies	5 (3.1%)	2 (1.5%)	0.463
It is not relevant	12 (7.4%)	18 (13.4%)	0.084
I don't know	100 (61.3%)	76 (56.7%)	0.419
2) Regarding studies on human normal temperature, which one do you use daily? (select the right answer)	Pediatrics (n=162)	Other physicians(n=134)	P

Average individual normal temperature	26 (16.1%)	18 (13.4%)	0.529
Maximum individual normal temperature	1 (0.6%)	4 (3.0%)	0.180
Average population normal temperature	86 (53.1%)	76 (56.7%)	0.532
Maximum population normal temperature [#]	19 (11.7%)	15 (11.2%)	0.886
I don't know	30 (18.5%)	21 (15.7%)	0.519
3) How many fever definitions do you know? (select the right answer)	Pediatrics (n=160)	Other physicians(n=133)	P
One	29 (18.1%)	44 (33.1%)	0.003*
Two	34 (21.2%)	22 (16.5%)	0.307
Three [#]	22 (13.8%)	22 (16.5%)	0.505
It is not relevant	29 (18.1%)	18 (13.6%)	0.286
I don't know	46 (28.8%)	27 (20.3%)	0.096
4) About fever definitions (select the wrong answer)	Pediatrics (n=161)	Other physicians(n=133)	P
Higher than normal for the individual, depending on the anatomic site of evaluation	20 (12.4%)	10 (7.5%)	0.167
More than 1°C above the average individual temperature, depending on the anatomic site of evaluation	27 (16.8%)	18 (13.5%)	0.443
Equal or higher than 37.4°C (99.3°F) axillary temperature	56 (34.8%)	46 (34.6%)	0.972
Equal or higher than 38.0°C (100.4°F) axillary temperature [#]	45 (27.9%)	48 (36.1%)	0.135
I don't know	13 (8.1%)	11 (8.3%)	0.951
5) About subfebrile definition (select the right answer)	Pediatrics (n=163)	Other physicians(n=135)	P
Precedes fever	9 (5.5%)	4 (3.0%)	0.288
Temperatures between 37.1–37.5°C (98.8–99.5°F)	20 (12.3%)	28 (20.7%)	0.044*
Temperatures between 37.5–38.0°C (99.5–100.4°F)	67 (41.1%)	70 (51.9%)	0.055
Does not exist [#]	59 (36.2%)	30 (22.2%)	0.010*
I don't know	8 (4.9%)	3 (2.2%)	0.356
6) In ambulatory, how can we assess core temperature (select the right answer)	Pediatrics (n=162)	Other physicians(n=134)	P
Body temperature	29 (17.9%)	34 (25.4%)	0.118
Axillary temperature	4 (2.4%)	11 (8.2%)	0.025*
Rectal temperature [#]	44 (27.2%)	27 (20.1%)	0.160
Rectal or tympanic temperature [#]	44 (27.2%)	23 (17.2%)	0.041*
I don't know	41 (25.3%)	39 (29.1%)	0.464
7) What is the most reliable anatomic site for temperature measurement? (select the right answer)	Pediatrics (n=163)	Other physicians(n=133)	P
Axillary	27 (16.6%)	19 (14.3%)	0.594
Oral	5 (3.1%)	1 (0.8%)	0.229
Rectal [#]	119 (73.0%)	88 (66.1%)	0.205
Temporal	0 (0.0%)	1 (0.8%)	0.449
Tympanic	12 (7.3%)	24 (18.0%)	0.005*
8) What is the least reliable anatomic site for temperature measurement? (select the right answer)	Pediatrics (n=160)	Other physicians(n=132)	P
Axillary	15 (9.4%)	15 (11.3%)	0.575
Oral	28 (17.5%)	22 (16.7%)	0.855
Rectal	3 (1.9%)	2 (1.5%)	0.815
Temporal [#]	98 (61.2%)	85 (64.4%)	0.568
Tympanic	16 (10.0%)	8 (6.1%)	0.224

9) Knowing that temperature differs according to anatomic evaluation site (select the right answer)	Pediatrics (n=162)	Other physicians(n=134)	P
Axillary < tympanic < rectal [#]	85 (52.5%)	86 (64.2%)	0.042*
Axillary < tympanic = rectal	56 (34.5%)	34 (25.4%)	0.087
Axillary = tympanic = rectal	0 (0.0%)	0 (0.0%)	-
Axillary = oral < rectal	16 (9.9%)	8 (5.9%)	0.220
I don't know	5 (3.1%)	6 (4.5%)	0.529
10) About the difference between rectal and axillary temperature: (select the wrong answer)	Pediatrics (n=162)	Other physicians(n=134)	P
Varies between 0.5–1.0°C (0.9–1.8°F) [#]	64 (39.5%)	70 (52.2%)	0.028*
Varies on average ±1.0°C (1.8°F)	27 (16.7%)	24 (17.9%)	0.778
Varies between 0–2.0°C (0–3.6°F) in apyrexia	24 (14.8%)	12 (9.0%)	0.125
Varies between 0–3.0°C (0–5.4°F) in fever	33 (20.4%)	17 (12.7%)	0.079
I don't know	14 (8.6%)	11 (8.2%)	0.894
11) Regarding fever, hyperthermia and hyperpyrexia concepts (select the right answer)	Pediatrics (n=163)	Other physicians(n=135)	P
Hyperthermia = fever	11 (6.7%)	18 (13.3%)	0.053
Hyperpyrexia = hyperthermia	12 (7.4%)	7 (5.2%)	0.454
Hyperthermia = endogenous warming	45 (27.6%)	41 (30.4%)	0.572
Hyperthermia = exogenous warming [#]	77 (47.2%)	52 (38.5%)	0.145
I don't know	18 (11.1%)	17 (12.6%)	0.662

Legend: #correct answer; *p<0.05

Table 4 - Comparison between answers of pediatricians and pediatric residents

1) Regarding population studies on human normal temperature (select the right answer?)	Pediatricians (n=110)	Pediatric residents (n=53)	P
All cross-sectional studies [#]	18 (16.4%)	8 (15.1%)	0.836
Cross-sectional and longitudinal studies	12 (10.9%)	8 (15.1%)	0.446
All longitudinal studies	3 (2.7%)	2 (3.8%)	0.661
It is not relevant	10 (9.1%)	2 (3.8%)	0.340
I don't know	67 (60.9%)	33 (62.2%)	0.868
2) Regarding studies on human normal temperature, which one do you use daily? (select the right answer)	Pediatricians (n=109)	Residents (n=53)	P
Average individual normal temperature	19 (17.4%)	7 (13.2%)	0.492
Maximum individual normal temperature	1 (0.9%)	0 (0.0%)	0.673
Average population normal temperature	54 (49.6%)	32 (60.4%)	0.195
Maximum population normal temperature [#]	12 (11.0%)	7 (13.2%)	0.683
I don't know	23 (21.1%)	7 (13.2%)	0.225
3) How many fever definitions do you know? (select the right answer)	Pediatricians (n=109)	Residents (n=51)	P
One	16 (14.7%)	13 (25.5%)	0.098
Two	23 (21.1%)	11 (21.6%)	0.946
Three [#]	16 (14.7%)	5 (9.8%)	0.395
It is not relevant	25 (22.9%)	4 (7.8%)	0.021*
I don't know	29 (26.6%)	18 (35.3%)	0.261

4) About fever definitions (select the wrong answer)	Pediatricians (n=108)	Residents (n=53)	P
Higher than normal for the individual, depending on the anatomic site of evaluation	12 (11.1%)	8 (15.1%)	0.471
More than 1°C above the average individual temperature, depending on the anatomic site of evaluation	15 (13.9%)	12 (22.6%)	0.162
Equal or higher than 37.4°C (99.3°F) axillary temperature	40 (37.0%)	16 (30.2%)	0.391
Equal or higher than 38.0°C (100.4°F) axillary temperature [#]	33 (30.6%)	12 (22.6%)	0.293
I don't know	8 (7.4%)	5 (9.4%)	0.760
5) About subfebrile definition (select the right answer)	Pediatricians (n=110)	Residents (n=53)	P
Precedes fever	7 (6.4%)	2 (3.8%)	0.719
Temperatures between 37.1–37.5°C (98.8–99.5°F)	16 (14.5%)	5 (9.4%)	0.362
Temperatures between 37.5–38.0°C (99.5–100.4°F)	41 (37.3%)	25 (47.2%)	0.228
Does not exist [#]	40 (36.4%)	19 (35.8%)	0.949
I don't know	6 (5.4%)	2 (3.8%)	0.486
6) In ambulatory, how can we assess core temperature (select the right answer)	Pediatricians (n=109)	Residents (n=53)	P
Body temperature	18 (16.5%)	11 (20.8%)	0.509
Axillary temperature	4 (3.7%)	0 (0.0%)	0.304
Rectal temperature [#]	35 (32.1%)	10 (18.9%)	0.077
Rectal or tympanic temperature [#]	33 (30.3%)	11 (20.7%)	0.201
I don't know	19 (17.4%)	21 (39.6%)	0.002*
7) What is the most reliable anatomic site for temperature measurement? (select the right answer)	Pediatricians (n=110)	Residents (n=53)	P
Axillary	15 (13.6%)	12 (22.6%)	0.155
Oral	5 (4.6%)	0 (0.0%)	0.174
Rectal [#]	81 (73.6%)	38 (71.7%)	0.724
Temporal	0 (0.0%)	0 (0.0%)	-
Tympanic	9 (8.2%)	3 (5.7%)	0.752
8) What is the least reliable anatomic site for temperature measurement? (select the right answer)	Pediatricians (n=108)	Residents (n=52)	P
Axillary	14 (13.0%)	2 (3.9%)	0.069
Oral	15 (13.9%)	13 (25.0%)	0.088
Rectal	2 (1.8%)	1 (1.9%)	0.698
Temporal [#]	70 (64.8%)	27 (51.9%)	0.102
Tympanic	7 (6.5%)	9 (17.3%)	0.034*
9) Knowing that temperature differs according to anatomic evaluation site (select the right answer)	Pediatricians (n=109)	Residents (n=53)	P
Axillary < tympanic < rectal [#]	54 (49.5%)	31 (58.5%)	0.285
Axillary < tympanic = rectal	39 (35.8%)	17 (32.1%)	0.642
Axillary = tympanic = rectal	0 (0.0%)	0 (0.0%)	-
Axillary = oral < rectal	11 (10.1%)	5 (9.4%)	0.895
I don't know	5 (4.6%)	0 (0.0%)	0.134
10) About the difference between rectal and axillary temperature: (select the wrong answer)	Pediatricians (n=109)	Residents (n=53)	P
Varies between 0.5–1.0°C (0.9–1.8°F) [#]	41 (37.6%)	22 (41.5%)	0.633
Varies on average ±1.0°C (1.8°F)	18 (16.5%)	9 (17.0%)	0.940

Varies between 0–2.0°C (0–3.6°F) in apyrexia	17 (15.6%)	7 (13.2%)	0.688
Varies between 0–3.0°C (0–5.4°F) in fever	23 (21.1%)	10 (18.9%)	0.741
I don't know	10 (9.2%)	5 (9.4%)	0.582
11) Regarding fever, hyperthermia and hyperpyrexia concepts (select the right answer)	Pediatricians (n=110)	Residents (n=53)	P
Hyperthermia = fever	11 (10.0%)	1 (1.9%)	0.106
Hyperpyrexia = hyperthermia	11 (10.0%)	1 (1.9%)	0.106
Hyperthermia = endogenous warming	28 (25.4%)	17 (32.1%)	0.376
Hyperthermia = exogenous warming [#]	51 (46.4%)	26 (49.0%)	0.747
I don't know	9 (8.2%)	8 (15.1%)	0.176

Legend: #correct answer; *p<0.05

DISCUSSION

Studies published about the knowledge of health professionals regarding fever have mainly focused the concept of fever phobia and fever treatment, providing a picture of caregivers' fever phobia.^{1,3,5,7-9,11,12,14,36} However, the present study had a different scope, similar to the one conducted by Mackowiak *et al.*, and focused on the basic concepts of evaluating and quantifying fever.¹⁶

“Normal temperature” varies from person to person according to age, sex, race, activity level, time of day, and anatomical site of measurement and is regulated through the thermoregulatory process within a specific range of values.^{2,7,16,17,20,28} In this study, only 10.6% of respondents knew how studies leading to the definition of “normal temperature” were conducted and almost 70% did not question the traditional fever definition, suggesting that health professionals frequently forget that individual body temperature is not an exception to other biological phenomena in which variability is the rule. The idea of a standard “normal body temperature” based on the highest population value, irrespective of intrinsic individual variability, has no physiological basis.^{2,23,25}

The best individual fever definition is a “rise in temperature above the normal daily range of each individual”.^{18,23-25} As most people do not know their temperature range, a fever definition of “temperature 1.0°C (1.8°F) above the individual average at a specific anatomic site” is significantly more precise than population-level definitions.^{2,18}

Overall, 73.5% of health professionals acknowledged the existence of “subfebrile” temperatures. Individual-centred fever definitions eliminate the need of a “subfebrile” concept, which represents a misconception that persists to compensate the erroneous use of a population-based “normal temperature” concept that implies that a range of temperatures can simultaneously indicate normality or illness.^{18,29}

Peripheral body temperature is significantly different from core temperature.^{2,15,17,20,30} Although the non-invasive temperatures that theoretically better correlate with core temperatures are rectal and tympanic, the last is greatly influenced by age and measurement technique.^{2,4,15,17,19,28,34} It requires a correct sensor adjustment to the tympanic membrane, in order to guide infrared rays while avoiding

cold air flow interference in the ear canal. This can be hindered by curvature of the ear canal and/or by interposition of earwax, justifying the lower accuracy of this method compared to rectal measurement.^{2,17,20,30,32,37}

Acceptance of current fever definitions without considering the anatomical site of evaluation was an issue also pointed out by Mackowiak *et al.*.^{4,14,16,38} This suggests that health professionals in Portugal almost exclusively use the axillary and/or tympanic temperatures, without questioning the accuracy of these methods and considering them identical. However, compared to rectal temperature and regardless of age, measurement of axillary temperature does not exceed 75% sensitivity.^{2,22,34} The peripheral vasoconstriction which occurs in thermal rise justifies a dynamic difference between rectal and axillary temperature up to 3.0°C.^{2,17,20,28,30,32,34,39}

Oral temperature was considered the least reliable by 19.5% of respondents. Traditional issues can justify the little use of this method in Portugal and its consequent devaluation. Oral is more accurate than axillary temperature, but less accurate than rectal temperature.^{2,23,32,34}

Temperature evaluation in the temporal area is the least accurate, with the lowest sensitivity in fever diagnosis and a high false-positive rate, due to being strongly influenced by environmental conditions.^{2,6,17,20,30,35}

This study suggests that 41% of health professionals confuse hyperthermia with fever. This confusion is perpetuated in medical literature, highlighting the lack of knowledge regarding fever pathophysiology.^{9,40}

The present study aims to suppress two gaps in the literature by providing two individual-centred fever definitions, on the one hand, and assessing health professionals' knowledge regarding basic concepts of fever and clinical thermometry, on the other. However, it has some limitations: a convenience sample was used, which was validated in a small group of professionals, and it did not analyse the circadian rhythm of normal temperature or thermometer contact time, required for an accurate temperature assessment. These are two particularly relevant issues that should be addressed in future studies.

CONCLUSION

Many health professionals do not have a consolidated knowledge regarding clinical thermometry and how to correctly define “normal temperature” and fever. It is questionable to further investigate caregivers’ knowledge about fever before they self-assess their own knowledge.

Fever research studies, in which a numerical definition of fever is required, should not be confused with the clinical evaluation of patients, who have their own physiologic temperature.

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