



Facial injury patterns in victims of intimate partner violence

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Abstract

Purpose To evaluate the imaging findings of facial injuries in patients reporting intimate partner violence (IPV).

Methods A retrospective review of radiology studies performed for 668 patients reporting IPV to our institution's violence prevention support program identified 96 patients with 152 facial injuries. Demographics, imaging findings, and clinical data obtained from a review of the electronic medical records (EMR) were analyzed to categorize injury patterns.

Results The study cohort consisted of 93 women and 3 men with a mean age of 35 years (range 19–76; median 32). At the time of presentation, 57 (59.3%) patients reported IPV as the mechanism of injury. The most frequent site of injury was the midface, seen in 65 (67.7%) patients. The most common fracture sites were the nasal bones (45/152, 29.6%), followed by the mandible (17/152, 11.1%), and orbits (16/152, 10.5%). Left-sided injuries were more common (90/152; 59.2%). A vast majority of fractures (94.5%) showed minimal or no displacement. Over one-third of injuries (60/152, 39.4%) demonstrated only soft tissue swelling or hematoma without fracture. Associated injuries were seen most frequently in the upper extremity, occurring synchronously in 11 (11.4%) patients, and preceding the index facial injury in 20 (21%) patients.

Conclusion Advances in knowledge.

The midface was the most frequent location of injury in victims of intimate partner violence, and the nasal bone was the most commonly fractured facial bone. Recognizing these injury patterns can help radiologists suspect IPV and prompt them to discuss the possibility of IPV with the clinical providers.

Keywords Facial trauma · Facial fractures · Intimate partner violence (IPV) · Domestic violence

Introduction

Intimate partner violence (IPV), defined as physical or sexual violence, stalking, or psychological harm by a current or former partner or spouse [1], is a highly prevalent and critical public health issue. According to the World Health Organization (WHO), 27% of women worldwide aged 15 to 49 have faced some form of IPV [2]. Within the USA, the Centers for Disease Control and Prevention (CDC) reports 35.6% of women and 28.5% of men have been victims of IPV, including rape, physical violence, and stalking [3]. Recently, due to the coronavirus pandemic, there has been

a surge in the incidence of domestic violence related to physical restrictions, isolation, loss of income, stress, and anxiety [4, 5]. Studies have shown that victims of IPV are more prone to detriments to both their physical and mental health [6–8]. IPV victims are more likely to sustain physical injuries (e.g., to the head, face, neck, thorax, and abdomen), suffer from gynecologic conditions including sexually transmitted diseases, and experience chronic pain, neurologic sequelae, and gastrointestinal disorders [6]. Women who recently experienced IPV were more likely to display depressive symptoms [7]. Finally, an association with limitations in social functioning was seen in women who experience current or past IPV [8]. The social costs of IPV impact society in the form of more frequent use of healthcare; women who experience IPV reportedly seek medical care three times more frequently than women who do not [6]. Because of

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the severe psychosocial health consequences linked to IPV, early detection and intervention are critical in the healthcare setting.

Over 88% of IPV victims present to the Emergency Department (ED) with facial injuries. Conversely, there is a greater than 50% likelihood of IPV in a woman presenting with facial injury to the ED [9–11]. In fact, compared to women with injuries limited to other areas of the body, women presenting to the ED with head, neck, and facial injuries are 7.5 times more likely to be victims of IPV [12]. It has been hypothesized that the face is a common target for acts of physical aggression as it is easily reached, being located at the level of the aggressor's arm, or additionally out of the aggressor's desire to impact the victim's self-esteem consciously or unconsciously [13]. Common mechanisms of facial injuries in IPV victims include blunt injuries from punching, kicking, or assault by household objects [14, 15]. Although screening in the emergency department has increased IPV detection, the proportion of women identified remains extremely low (only 5–30%), suggesting IPV is still underdiagnosed, likely due to a combination of patient and physician-related factors [16–18]. Radiologists have increasingly been highlighted as playing a pivotal role in identifying victims of IPV, due to their ability to objectively assess injuries on imaging in a unique capacity that may be less restricted by the psychological and social screening barriers which often impede IPV discovery—e.g., fear of offending the patient with direct questioning [4, 19, 20]. Therefore, the purpose of our study was to categorize the spectrum of facial injuries seen on imaging among IPV victims presenting to a level I trauma center in the Northeast United States. By identifying the most common injury patterns as well as associated injuries, the radiologist may appropriately raise their suspicion for IPV over accidental trauma if such injuries are present in radiological studies, especially in patients who are not forthcoming.

Materials and methods

This Health Insurance Portability and Accountability Act (HIPAA) compliant retrospective study was approved by the Institutional Review Board (IRB) at the institution where our IPV patients presented. Informed consent was waived.

Cohort:

Our institution's domestic violence prevention and intervention program provided a list of patients who reported IPV over a 5-year period from June 2013 to June 2018.

Of the 1248 patients reporting IPV, 580 patients did not have radiological studies and were therefore excluded. A total of 18,606 radiology reports for the 668 patients with available radiological studies were reviewed by four radiologists undergoing training in emergency radiology fellowships to identify 104 radiological studies positive for facial injuries. All radiological studies (36 head CT and 72 face CT studies) positive for facial injuries were then reviewed and analyzed by one emergency radiology fellow in consultation with an attending emergency radiologist of 16 years of clinical experience. In total, 96 patients with 152 unique facial injuries constituted our study cohort.

The information on type of injury (i.e., fractures and soft tissue swelling) and anatomic location were obtained from radiological studies, while demographics and additional clinical data pertaining to each facial injury were collected from the electronic medical record (EMR) and analyzed for all 96 patients to better understand the most frequently noted patterns of injuries and their associations. Demographic information collected included age, sex, and race. Additional psychosocial data obtained from the EMR included a history of substance abuse and the presence of mental illness, which were recorded due to their known association with IPV [21]. The reported mechanism of injury and whether screening for IPV was documented at time of presentation were also recorded.

Analysis of facial injuries

Sites of facial injuries were categorized into thirds—upper (frontal and supraorbital), mid (orbit, maxilla, zygoma), and lower face (mandibular and temporomandibular joint) fractures, and soft tissue injuries. The laterality of injury (right or left) was also noted. Soft tissue swelling visible on CT was recorded as a separate injury for each region. However, if a concurrent fracture was observed, the overlying soft tissue swelling in the same facial region was not scored as an additional injury. For studies demonstrating multiple injuries, each distinct injury was assigned a separate count. Fractures were characterized as acute or chronic and, when present, the presence of displacement and comminution was noted. Concomitant injuries to parts of the body other than the face that occurred synchronously with the index facial injury were recorded. Finally, injuries preceding and following the index facial injury were also recorded. Statistical analyses were conducted in Excel (version 16.45, Microsoft Office 365, Redmond, WA). For continuous data, we reported the mean, median, and range, while for categorical data, we reported the mean and percentages of all patients or all injuries.

Table 1 Patient characteristics: IPV victims with facial trauma

Total patients: 96	
Sex ratio (M:F)	3:93
Mean age	35 (19–76) years (median = 32)
Race	
White	37 (38.5%)
Black (African American)	36 (37.1%)
Hispanic	13 (13.5%)
Asian	3 (3.15%)
Other/not recorded	7 (7.2%)
Language spoken	
English	83 (86.4%)
Non-English (Spanish, Chinese, Vietnamese, other)	13 (13.6%)
IPV screen at the time of injury	
Yes	41 (42.7%)
No	19 (19.7%)
Data not available	36 (37.5%)
Mechanism of injury	
Assault	57 (59.3%)
Fall	15 (15.6%)
MVC	4 (4.1%)
Other	3 (3.1%)
Mechanism not specified	17 (17.7%)
History substance abuse	
Present (alcohol, marihuana, cocaine, heroin)	37 (38.5%)
Absent	7 (7.2%)
History not available	52 (54.1%)
Psychiatric history	
Present (depression, anxiety, bipolar disorder, suicidal ideation)	39 (40.6%)
Absent	7 (7.2%)
History not available	50 (52%)

Results

Demographics and risk factors

Our cohort consisted of 96 patients presenting with a total of 152 facial injuries (Table 1) over the 5-year study period. Mean age was 35 years (range 19–76; median age 32 years; *SD* = 13). There were 93 women and 3 men with no gender non-binary patients (Table 1). 38.5% of patients were White, 37.1% Black, and 13.5% Hispanic. The majority of patients were English speaking (86%). Over one-third of patients reported alcohol or drug dependence (38.5%) and a substantial percentage reported underlying psychiatric conditions such as depression, anxiety, bipolar disorder, or suicidal ideation (40.6%).

Reported history and IPV

Less than half (42.7%) of patients had documentation of screening or questioning about IPV-related injury listed in their EMR at the time of their facial injury. The most commonly reported mechanism of injury was physical assault by an intimate partner (59.3%); however, 15.6% of patients reported fall as the underlying cause of their injury.

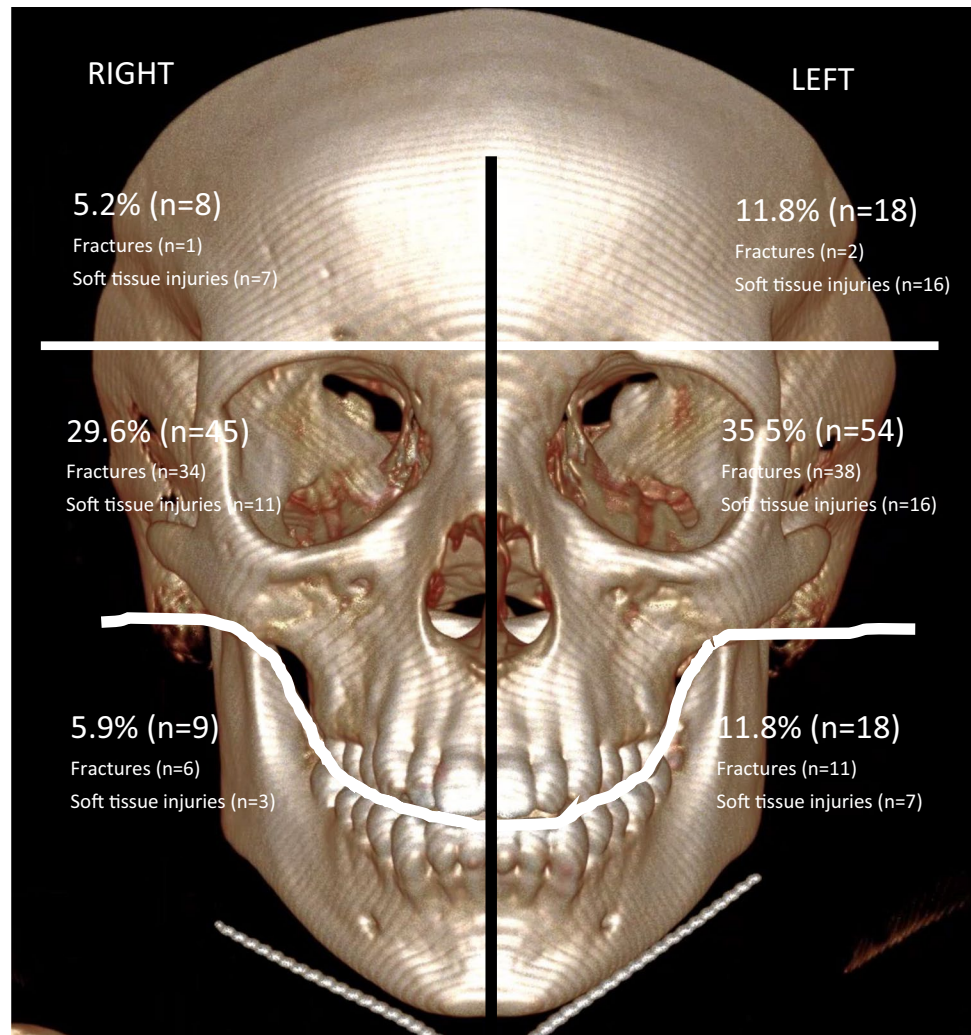
Facial injury distribution

A total of 152 injuries were identified in the radiological studies reviewed for 96 patients. Of these, 26 injuries (20.8%) were located in the upper face, 99 injuries (65.1%) in the midface, and 27 injuries (17.7%) in the lower face (Fig. 1). Overall, there was a predominance of facial fractures (92/152; 60.5%) compared to isolated soft tissue injuries (60/152; 39.4%). Of the 92 recorded facial fractures, 72 (78%) were located in the midface, 17 (18.4%) in the lower face, and 3 (3.2%) in the upper face (Table 2) with 60 (39.4%) soft tissue injuries in the upper, mid, and lower face collectively (Fig. 1). Left-sided injuries were slightly more common among all facial injuries (90/152; 59.2%) and facial fractures (51/92; 55%) with 53.1% (51/96) of patients demonstrating only left-sided facial injuries on their radiological studies.

Facial fractures

Fractures represented 11.5% (3/26) of the upper, 72.7% (72/99) of the mid, and 62.9% (17/27) of the lower face injuries. Anatomic distributions of the 92 fractures are recorded in Table 2. Fracture of the nasal bone was the most commonly detected facial fracture in our cohort (45/92; 48.9%) with an almost equal representation of left and right fractures (right = 49%, left = 51%). Mandibular fractures were second most common, representing 18.4% (17/92) of detected facial fractures (right = 35.2%, left = 64.7%). While most mandibular fractures were isolated to one laterality, two instances of bilateral fractures were noted—one involving the mandibular body on the right and the mandibular angle on the left, and the second involving the mandibular body bilaterally. Orbital fractures were the third most common, representing 17.3% of all facial fractures (right = 48%, left = 52%). The medial orbital wall was the most commonly affected orbital region (9/16, 56.2%) followed by the orbital floor (6/16; 37.5%). Maxillary fractures comprised 10.8% (10/92) of all fractures with equal distribution on the left and right. All fractures involved the anterior wall of the maxillary sinus with 3 involving the central anterior wall, 3 anteromedial, 2 anterolateral, and 2 anterior inferior walls. There were only 3 frontal/supraorbital fractures and 1 zygomatic

Fig. 1 Distribution of facial injuries



fracture at its frontal articulation. Only 5 (8%) fractures were comminuted or showed significant displacement; these included fractures of the nasal bone ($n = 3$), right orbital floor ($n = 1$), and left mandibular condyle ($n = 1$). The remainder of the fractures were either minimally displaced or non-displaced. Three patients had incidental and isolated chronic fractures, with two demonstrating chronic nasal bone fractures and one demonstrating a chronic zygomatic arch fracture.

Nasal bone fractures ($n = 45$) were most often seen in conjunction with periorbital or supraorbital soft tissue swelling or orbital fracture (17/45). Mandibular fractures ($n = 17$) were most often associated with midface injuries such as maxillary bone fractures (3 injuries), bilateral nasal bone fractures (2 injuries), and periorbital soft tissue swelling (2 patients). Orbital wall fractures ($n = 16$) were commonly associated with ipsilateral nasal bone fracture ($n = 4$).

Soft tissue injuries

All acute fractures were associated with soft tissue swelling. There were 60 soft tissue injuries not associated with fractures, of which there were 11 (18.3%) counts of upper face/frontal scalp soft tissue swelling, 12 (20%) frontal subgaleal hematomas, 27 (45%) counts of midface soft tissue swelling, including 8 periorbital hematomas, and 10 (16.6%) counts of lower face soft tissue swelling. Periorbital soft tissue swelling was the most common type of isolated facial injury ($n = 22$).

Concomitant injuries

In total, 19 out of 152 facial injuries (12.5%) were associated with additional injuries to body parts other than the face visible on radiological studies performed during the same visit as the index facial injury (Table 3). In 11/19 (57.5%) injuries,

Table 2 Distribution of facial fractures in patients of IPV

Fractures	Left	Right	Total (%)
Upper face			
Frontal bone including supraorbital bone	2	1	3 (3.2)
Midface			
Orbital bone	9	7	16 (17.3)
Floor	2	4	6
Medial wall	6	3	9
Roof	0	0	0
Lateral wall	1	0	1
Nasal bone	23	22	45 (48.9)
Zygoma	1	0	1 (1.0)
Maxilla including maxillary sinus	5	5	10 (10.8)
Lower face			
Mandible	11	6	17 (17.7)
Angle	1	1	2
Symphysis	0	0	0
Condyle	1	0	1
Body	7	3	10
Ramus	2	2	4

concomitant injuries were seen involving the upper extremity (Fig. 2). Of these, 5 facial injuries had synchronous upper extremity fractures; specifically, 2 patients had phalangeal fractures, 1 had radial fracture, 2 had ulnar fracture, and 6 patients had isolated soft tissue swelling. The second most frequently affected region was the lower extremity, seen in association with 5/19 (26.3%) facial injuries. Of these, 4 demonstrated isolated soft tissue swelling of the ankle. Additional less frequently noted concomitant injuries included soft tissue swelling of the neck (3), soft tissue swelling over the chest and/or abdomen (5), and thoracic spine fracture (1), as well more serious internal injuries such as intracranial hemorrhages (3), internal jugular vein injury (1), pneumothorax (1), pneumomediastinum (1), and liver and diaphragmatic injury (1). Seven patients suffered more than 1 synchronous injury to other body parts, including bruising of multiple regions, including the upper extremities, neck, chest, and abdomen. Two patients were victims of penetrating injuries from stabbing and as a result demonstrated multiple deep organ injuries.

Injuries preceding and following the index facial injury

Twenty (20.8%) patients sustained upper extremity injuries prior to the index facial injury, with 26 injuries recorded in total (Table 3) over a range of 8 months to 25 years (mean 65.3 months; median 49.5 months). Six patients (6.2%) reported upper extremity injuries subsequent to the index facial injury over the range of 4 months to 6 years (mean 46.3 months; median 53).

Twelve patients sustained lower extremity injuries prior to the index facial injury (range 4–181 months, mean 53.1, median 39 months) and 10 patients sustained lower extremity injury after the index facial injury (range 3–289 months, mean 63 months, median 26 months).

Six patients had head and neck injuries before (range 2–25 months, mean 19.2 months, median 19 months) and 10 had after the index facial injury (range 1–65 months, mean 25.7 months, median 26 months).

Seven patients had a history of torso injuries prior to index facial trauma incident (range 3–150 months, mean 49.6 months, median 25 months) and 7 patients had torso injuries after the index injury (range 3–190 months, mean 63.2 months, median 26 months) (Figs. 3 and 4).

Recurrent facial injury

Recurrent facial injuries were seen in 8 out of 96 patients. Eleven out of 96 patients underwent at least two facial CT exams with interval time periods ranging from 5 months to 6.2 years (mean 24.2 months; median 20 months) (Figs. 2 and 3). Of these, the initial injuries involved various facial zones, including the upper face (1 frontal bone fracture and 1 frontal soft tissue laceration), the midface (2 bilateral nasal bone fractures, 1 orbital fracture, and 1 instance of periorbital soft tissue swelling), and the lower face (2 mandibular fractures). However, subsequent injuries in all 8 patients congregated in the midface, with 1 patient sustaining an orbital wall fracture, 2 sustaining nasal bone fractures, and 5 sustaining isolated midface soft tissue swelling.

Discussion

To date, there has been limited literature discussing the crucial role radiologists can play in detecting IPV [19–24]. Our study is the first systematic attempt to explore 152 facial injuries seen on radiological studies of 96 IPV victims reporting IPV to the domestic violence prevention and intervention program at a level 1 trauma center. The midface was involved in 65% of injuries, and the nasal bone accounted for nearly one-third of all facial fractures. The upper extremity was the most common site for concomitant (11%) and preceding (21%) injury, while the lower extremity (10%) and torso (10%) injuries outnumbered upper extremity (6%) injuries subsequent to the index facial injury. In total, 6% of patients had recurrent injuries to the face, and while initial injuries were distributed in all 3 facial zones, subsequent injuries tended to localize to the midface.

Our calculated prevalence of 14% (96/688) for facial injuries in our IPV cohort is lower than that published in earlier studies, which reported a prevalence of 34 to 88% in IPV victims [25, 26]. One reason may be because of differences

Table 3 Non-facial injuries associated with the index facial injury in patients with IPV

	Injuries prior to index facial trauma	Injuries concomitant with facial trauma	Injuries after the index facial trauma
Upper extremity	20 (26)	11 (11)	6(6)
Number of patients (number of injuries)			
Duration range in months	8–300 (mean 65.3, median 49.5)		4–72 (mean 46.3, median 53)
Upper extremity injuries categorized	Soft tissue swelling (10) Phalangeal/metacarpal fracture/carpel (10) Radius fracture (5) Ulnar fracture (1)	Soft tissue swelling (6) Phalangeal/metacarpal fracture/carpel (2) Radius fracture (1) Ulna fracture (2)	Soft tissue swelling (3) Phalangeal/metacarpal fracture/carpel (3) Tibia (3) Ulnar (1)
Lower extremity	12 (12)	4 (5)	10 (11)
Number of patients (number of injuries)			
Duration range in months	4–181 (mean 53.1, median 39)		3–289 (mean 63, median 26)
Lower extremity injuries categorized	Soft tissue swelling (5) Phalanges/metatarsal/tarsal (6) Fibula (1)	left hip fracture (1) Soft tissue swelling (4)	Soft tissue swelling (6) Phalanges/metatarsal/tarsal (1) Tibia (3) Fibula (2)
Head, neck, spine	6(6)	6 (8)	10 (18)
Number of patients (number of injuries)			
Duration range in months	2–25 (mean 19.2, median 19)		1–65 (mean 25.7, median 26)
Head, neck, spine injuries categorized	Scalp hematoma (5) Thoracic vertebral fracture (1)	Intracranial hemorrhage (3) Neck soft tissue swelling (3) Internal Jugular vein injury (1) Thoracic spine injury (1)	Intracranial hemorrhage (2) Scalp hematoma (2) Facial fracture (3) Facial soft tissue swelling (5) Cervical spine fracture (1) Thoracic vertebral fracture (2) Lumbar fractures (3)
Torso	7 (12)	4 (8)	7 (12)
Number of patients (number of injuries)			
Duration range in months	3–150 (mean 49.6, median 25)		3–190 (mean 63.2, median 26)
Torso injuries categorized	Rib fracture (3) Clavicle (1) A–C joint separation (2) Sternal fracture (1) Soft tissue swelling chest or abdomen (2) Liver (1) Abortion (1) IUGR (1)	Pneumothorax (1) Pneumomediastinum (1) Liver and diaphragmatic injury (1) Soft tissue swelling on the chest, abdomen (5)	Rib fractures (6) Widened AC joint (1) Sternal fracture (1) Pneumothorax (2) Abdominal swelling (2)

in injury assessment. Our observations were based on radiological exams rather than physical exam findings, and therefore, subjective soft tissue injuries evaluated on exam may not have been apparent on CT for some patients. In fact, the most frequently reported injury type due to IPV based on clinical examination are contusions, followed by lacerations and strains or sprains [25]. Our cohort reflected a higher percentage of fractures than soft tissue injuries compared to prior studies, likely because only injuries of at least moderate severity, such as fractures or internal organ injuries,

warrant the treatment team ordering a radiological exam. For instance, frontal bone fracture was reported in 0.7% of IPV-related injuries in previous studies yet constituted 3.2% of injuries in our cohort [27]. The midface, consisting of the nasal bone, orbit, maxilla, and zygoma, is considered the main target area in IPV [28]. Soft tissue swelling in the mid face, in particular, is highly specific [28]. Our study showed a greater involvement of the midface, accounting for 65% of facial injuries compared to previous studies reporting a range of 24–50% [11, 27, 29, 30].

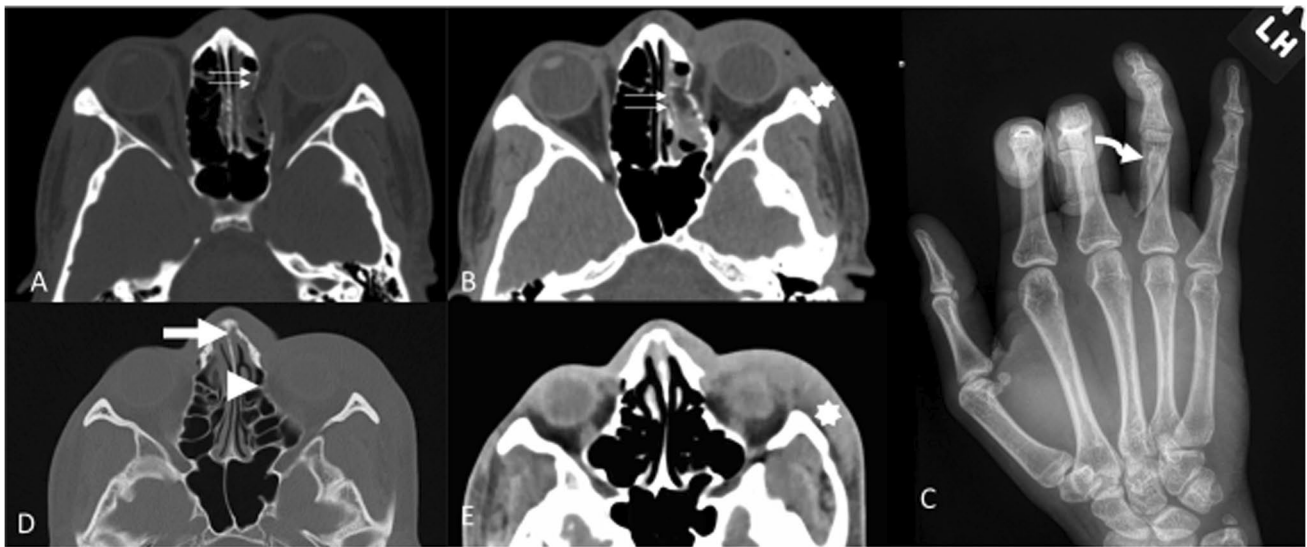


Fig. 2 Twenty-one-year-old women with recurrent facial injuries. Axial bone (A) and axial soft tissue window (B) CT images of the face show a blowout medial orbital wall fracture (two small arrows) associated with extensive periorbital soft tissue swelling (*). PA radiograph of the right hand (C) shows an associated oblique fracture of the proximal phalanx of the ring finger (curved arrow). One

year later, axial bone (D) and axial soft tissue (E) window CT images of the face show recurrent facial injury with left nasal bone fracture (bold arrow) with periorbital soft tissue swelling (*). It also shows a sequela to an old fracture of the medial orbital wall of the left orbit (arrowhead)

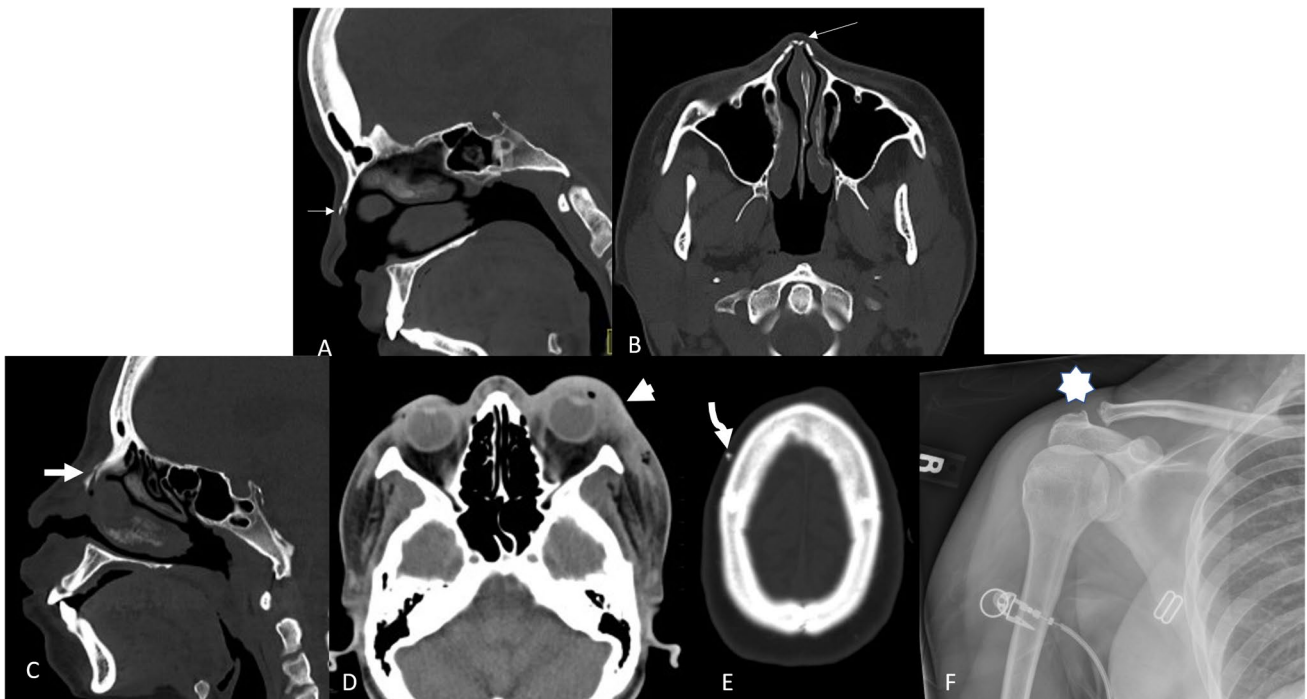


Fig. 3 Thirty-two-year-old woman with a history of assault. Sagittal (A) and axial (B) CT of the face in the bone window shows minimally displaced tip of nasal bone fracture (small arrows). Two years later, the same patient with a history of assault with a glass object, sagittal bone (C), axial soft tissue (D), and axial bone (E) window

CT of the head and face shows nasal bone fractures (bold arrow), extensive soft in the midface and periorbital region (arrowhead), and a small radiodense foreign body in the right frontal scalp (curved arrow), and an internal rotation radiograph of the right shoulder (F) shows widening of the acromioclavicular joint (*)

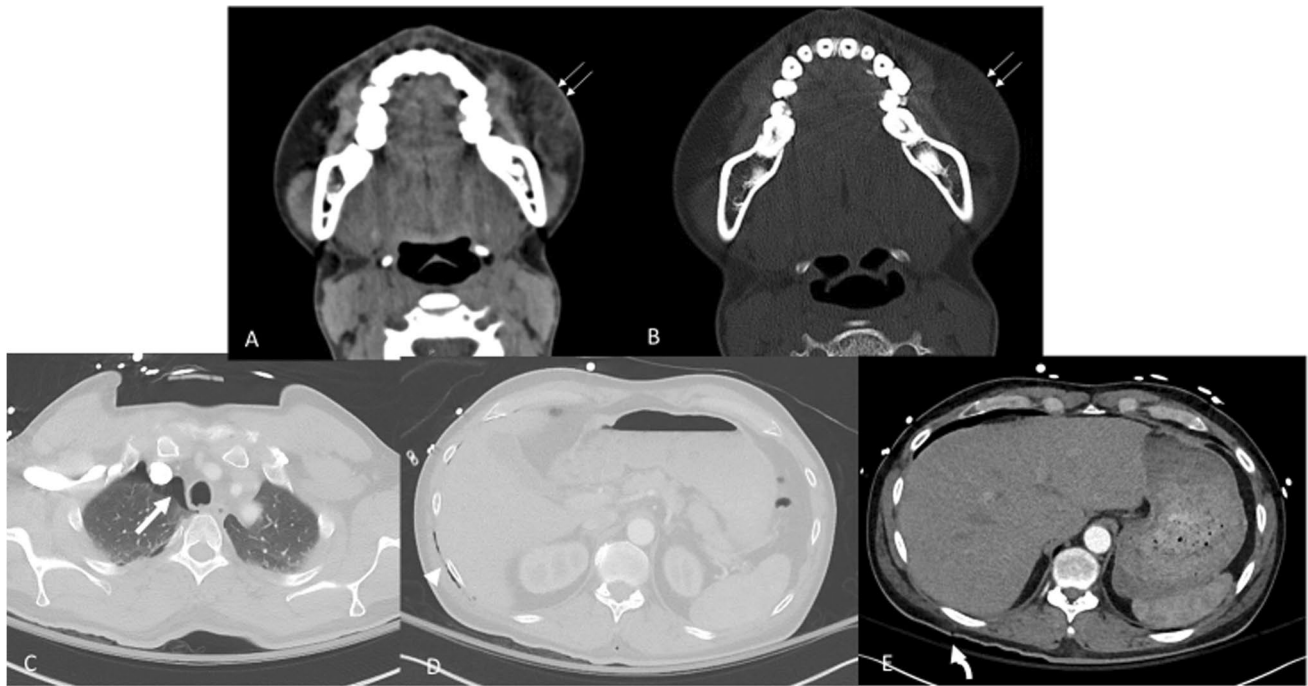


Fig. 4 Fifty-two-year-old women with a history of assault on the face. Axial soft tissue (A) and axial bone (B) CT of the face shows left lower face soft tissue swelling without fracture (small arrows). Five years later, the same patient presented to ED with a history of mul-

tle penetrating injuries with a knife. Axial CT of the chest in lung window (C, D) and soft tissue window (E) shows pneumothorax (arrow), soft tissue emphysema (arrowhead), and one of the sites of the entry wound in the right lower back (curved arrow)

Similar to previous studies [11, 31, 32], the nasal bone was the most common fracture location and was involved in up to one-third of facial fractures in our study. This is likely due to the prominent nature of the nose with respect to other structures in the face. Among IPV-related fractures in the 1352 patients identified as survivors of abuse from the National Trauma Data Bank (NTDB) Research dataset (a combined collection from 800 trauma centers across the USA), nasal bone fracture was the most common type, seen in 284 (21%) patients, followed by orbital and mandibular fractures [31]. A similar study by Salonen et al. [33] also found nasal bones to be the most common site of injury, seen in 256 (35%) patients out of a cohort of 727 patients. These included fractures of the nasal bone (42 unilateral and 185 bilateral), fractures of the nasal process of the maxilla (113 unilateral and 42 bilateral), and 79 fractures of the nasal septum. Within our cohort, 30 (31.2%) out of 96 patients had either isolated nasal bone fracture or fracture in combination with other injuries.

The second most common fracture location in our cohort was the mandible (18.4%), with almost 2/3 of fractures localizing to the left and involving the body of the mandible. Our percentages were more similar to that of Fisher et al. [9] who reported a mandibular fracture rate of 22% among IPV victims. Interestingly, prior studies performed by Huang et al. [30] and Zachariades et al. [10] had found a higher incidence

of mandibular fracture—42% and 39%, respectively. Nasal bone fracture was only the third most common site of facial bone fracture in Huang et al.'s study, following mandibular and zygomatic fractures [30]. Of note, Huang et al. analyzed all women admitted with traumatic facial injuries to the University of California Davis Medical Center over a 2-year period regardless of etiology, drawing from a different geographic study pool than our study. Additionally, the primary mechanism of injury documented by Huang et al. was motor vehicle accidents, with assault being the second most common. However, Huang et al. also noted multiple instances where facial injuries in women were not adequately documented, highlighting the fact that domestic violence is often under-reported. This suggests a potential difference in injury localization between facial injuries resulting from accidental trauma compared to IPV. Of note, Zachariades et al. [10] isolated a subset of women who suffered male violence from a known individual (husband, boyfriend, or blood-related relative) and found a similar trend, with mandibular fractures being the dominant fracture location, followed by zygomatic fracture, with only 1 case of nasal bone fracture. However, this was an extremely small subset of 39 women out of a total of 2308 trauma patients selected from a hospital in Greece over a 2.5-year period [10]. This difference could be related to the fact that mandibular and zygomatic fractures are arguably more debilitating than nasal bone fractures, and

therefore more likely to prompt the victim to seek medical attention. Many nasal bone fractures in the past (Zachariades's study was published in 1990) may have been under-represented due to under-reporting and lack of radiological exams. However, with the increased usage of multidetector CT in the emergency department, more subtle nasal bone fractures that may not cause obvious disfigurement may be detected. Additionally, our retrospective imaging analysis captured all fractures, including chronic ones that might not be recorded on the basis of clinical examination only.

Finally, the left side of the face is understandably more frequently targeted because of the right-handed dominance of the general population with a tendency for right-handed aggressors to strike the left side of the victim usually in the mid face area. Eggenesperger et al. [34] found that among 65 patients who presented to the University Hospital of Bern between 2000 and 2002 with assault related facial injuries, upper and mid facial fractures comprised 76% of all fractures with a 2:1 predominance favoring the left side. In our study, left-sided injuries constituted approximately 59.2% of all injuries. This slight discrepancy may be related to the higher sensitivity of CT, which may demonstrate subtle fractures contralateral to the side of impact.

Orbital fractures represented 17.3% of all facial fractures in our study, similar to previously reported occurrences ranging from 7 to 35–50% [14, 35, 36]. All orbital fractures were blowout fractures involving either the floor and/or medial wall, except for one fracture involving the lateral wall, similar to prior studies [27]. None of the fractures involving the maxilla was isolated in our cohort, with an overall incidence of 10% that was similar to previous studies reporting 10–24% [10, 30]. The low occurrence of supra-orbital rim fractures, which result from IPV victims sustaining a forceful blow to the head, is also similar to the previously reported incidence of 0.7% [27]. Finally, our study reflected only one case of zygomatic fracture (1%), a much lower incidence compared to previous studies reporting higher incidence rates of 10 to 25% [27, 37].

Within our cohort, the most common concomitant injuries were upper extremity fractures. These likely represent defensive fractures, sustained as the victim raises their arm to shield the face or central body from assault [38, 39]. Interestingly, the incidence of upper extremity injuries was higher prior to than following the index facial injury (20.8% compared to 6.2%) with a higher incidence of lower extremity injury subsequent to the index facial injury. One hypothesis for this trend may be behavioral. Early on, IPV victims may resist attack by defending themselves with their upper extremities, but over time may opt to flee the perpetrator due to the increasing severity of injuries and thereby injure their lower extremities. In comparison, the incidence of torso injuries was not significantly different following the index facial injury than preceding it. Importantly, these patterns

also underscore the significance of diagnosing IPV earlier in the cycle to prevent later more severe, life-threatening injuries and homicides that occur with recurrent escalating abuse. In fact, among the 1352 adult survivors of abuse from the NTDB from 2007 to 2014, facial fractures were more frequently observed in younger patients aged 18 to 39 years, compared to patients aged 60 years or older, who more often sustained rib and femur fractures [31]. A recent study by Khurana et al. [40] analyzing 2,096,955 IPV-related ED visits from the National Electronic Injury Surveillance System database has shown that older adults sustain a lower number of head and neck IPV-related injuries (47.6%) than younger adults (59.4%) but have more trunk fractures (38.4% vs 11.9%). Thus, facial injuries may represent a herald injury of more severe trauma to come, as there often exists an association between increasing severity of IPV and longer duration of abusive relationships between the victim and the aggressor (Fig. 4).

Our study had several limitations. First, our patient cohort was selected from a single institution and therefore may lack generalizability. Future studies may benefit from pooling patients presenting for traumatic indications at multiple institutions. Second, because we included all potentially violence-related facial injuries in this analysis, we may have erroneously included some presentations for routine trauma due to potentially unreliable narratives from IPV victims. On the other hand, our study may simultaneously underestimate the true IPV frequency, as many victims with less severe injuries may opt not to seek medical attention or undergo imaging. Furthermore, injuries in IPV victims and trauma patients might show significant overlap and our study does not look in analyzing statistical difference between the two patterns of facial injuries and it is a potential area of further research in this field. Additionally, some of these patients may have sought medical attention or underwent imaging at a separate institution with a different PACS database that is not available to our radiologists for review and therefore could not be included in our analysis. Finally, we only analyzed injuries for the patients who voluntarily reported to our IPV prevention program and would not have been able to assess facial injuries in IPV victims who did not connect with this program [41].

In conclusion, most IPV victims who presented to our institution with facial injuries were female and most commonly sustained injuries of the midface and nasal bone fractures. These were frequently either preceded by or occurred synchronously with upper extremity injuries, and both features, in the presence of an unclear presentation history, should prompt the radiologist to consider discussing suspicion for potential IPV as a mechanism of injury with the ordering physician. By recognizing the salient patterns of facial injuries seen in association with IPV, radiologists have the potential to become first-line detectors of these

often vastly under-reported and hidden cases. Equipped with cross-sectional imaging modalities such as CT and comprehensive trauma imaging protocols, radiologists have the unique advantage of being able to diagnose IPV objectively, rather than relying solely on self-reporting by the victim, and can thus facilitate early identification and rehabilitation [20, 22–24].

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Declarations

Conflict of interest B Khurana: GE Health Care Research Grant; Section Editor Emergency Radiology, UpToDate, Wolters Kluwer; Book Author, Cambridge University Press, ROKIT health care: research consultant. All other authors declare no competing interests.



References

- Intimate Partner Violence. 13 Oct 2021 [cited 18 Oct 2021]. Available: <https://www.cdc.gov/violenceprevention/intimatepartnerviolence/index.html>
- Website. Available: <https://www.who.int/news-room/fact-sheets/detail/violence-against-women>
- Black MC. National intimate partner and sexual violence survey: 2010 summary report. 2013.
- Gosangi B, Park H, Thomas R, Gujrathi R, Bay CP, Raja AS et al (2021) Exacerbation of physical intimate partner violence during COVID-19 pandemic. *Radiology* 298:E38–E45
- Chandan JS, Taylor J, Bradbury-Jones C, Nirantharakumar K, Kane E, Bandyopadhyay S (2020) COVID-19: a public health approach to manage domestic violence is needed. *Lancet Public Health* 5:e309
- Campbell JC (2002) Health consequences of intimate partner violence. *Lancet* 359:1331–1336
- Bonomi AE, Thompson RS, Anderson M, Reid RJ, Carrell D, Dimer JA et al (2006) Intimate partner violence and women's physical, mental, and social functioning. *Am J Prev Med* 30:458–466
- McCaw B, Golding JM, Farley M, Minkoff JR (2007) Domestic violence and abuse, health status, and social functioning. *Women Health* 45:1–23
- Fisher EB, Kraus H, Lewis VL Jr (1990) Assaulted women. *Plast Reconstr Surg* 86:161
- Zachariades N, Koumoura F, Konsolaki-Agouridaki E (1990) Facial trauma in women resulting from violence by men. *J Oral Maxillofac Surg* 48:1250–1253
- Arosarena OA, Fritsch TA, Hsueh Y, Aynehchi B, Haug R (2009) Maxillofacial injuries and violence against women. *Arch Facial Plast Surg* 11:48–52
- Perciaccante VJ, Ochs HA, Dodson TB. Head, neck, and facial injuries as markers of domestic violence in women. *J Oral Maxillofac Surg*. 1999;57: 760–2; discussion 762–3.
- Ferreira MC, Batista AM, Ferreira F de O, Ramos-Jorge ML, Marques LS. Pattern of oral-maxillofacial trauma stemming from interpersonal physical violence and determinant factors. *Dent Traumatol*. 2014;30: 15–21.
- Le BT, Dierks EJ, Ueek BA, Homer LD, Potter BF. Maxillofacial injuries associated with domestic violence. *J Oral Maxillofac Surg*. 2001;59: 1277–83; discussion 1283–4.
- Boyes H, Fan K (2020) Maxillofacial injuries associated with domestic violence: experience at a major trauma centre. *Br J Oral Maxillofac Surg* 58:185–189
- O'Doherty L, Hegarty K, Ramsay J, Davidson LL, Feder G, Taft A. Screening women for intimate partner violence in healthcare settings. *Cochrane Database Syst Rev*. 2015; CD007007.
- Kothari CL, Rhodes KV (2006) Missed opportunities: emergency department visits by police-identified victims of intimate partner violence. *Ann Emerg Med* 47:190–199
- Elliott L, Nerney M, Jones T, Friedmann PD (2002) Barriers to screening for domestic violence. *J Gen Intern Med* 17:112–116
- George E, Phillips CH, Shah N, Lewis-O'Connor A, Rosner B, Stoklosa HM, et al. Radiologic findings in intimate partner violence. *Radiology*. 2019;291: 62–69.
- Matoori S, Khurana B, Balcom MC, Koh D-M, Froehlich JM, Janssen S et al (2020) Intimate partner violence crisis in the COVID-19 pandemic: how can radiologists make a difference? *Eur Radiol* 30:6933–6936
- Coker AL, Davis KE, Arias I, Desai S, Sanderson M, Brandt HM et al (2002) Physical and mental health effects of intimate partner violence for men and women. *Am J Prev Med* 23:260–268
- Bhole S, Bhole A, Harmath C (2014) The black and white truth about domestic violence. *Emerg Radiol* 21:407–412
- Karangelis D, Karkos CD, Tagarakis GI, Oikonomou K, Karkos PD, Papadopoulos D et al (2011) Thoracic injuries resulting from intimate partner violence. *J Forensic Leg Med* 18:119–120
- Malek AM, Higashida RT, Halbach VV, Dowd CF, Phatouros CC, Lempert TE et al (2000) Patient presentation, angiographic features, and treatment of strangulation-induced bilateral dissection of the cervical internal carotid artery. Report of three cases *J Neurosurg* 92:481–487
- Loder RT, Momper L. Demographics and fracture patterns of patients presenting to US emergency departments for intimate partner violence. *J Am Acad Orthop Surg Glob Res Rev*. 2020;4. <https://doi.org/10.5435/JAAOS-Global-D-20-00009>
- Wu V, Huff H, Bhandari M (2010) Pattern of physical injury associated with intimate partner violence in women presenting to the emergency department: a systematic review and meta-analysis. *Trauma Violence Abuse* 11:71–82
- Goulart DR, Colombo L do A, de Moraes M, Asprino L. What is expected from a facial trauma caused by violence? *J Oral Maxillofac Res*. 2014;5: e4.
- Alessandrino F, Keraliya A, Lebovic J, Mitchell Dyer GS, Harris MB, Tornetta P 3rd et al (2020) Intimate partner violence: a primer for radiologists to make the “invisible” visible. *Radiographics* 40:2080–2097
- Shepherd JP, Gayford JJ, Leslie IJ, Scully C (1988) Female victims of assault. *J Craniomaxillofac Surg* 16:233–237
- Huang V, Moore C, Bohrer P, Thaller SR (1998) Maxillofacial injuries in women. *Ann Plast Surg* 41:482–484
- Porter A, Montgomery CO, Montgomery BE, Eastin C, Boyette J, Snead G (2019) Intimate partner violence-related fractures in the United States: an 8 year review. *J Fam Violence* 34:601–609
- Sterzik V, Duckwitz D, Bohnert M (2016) Accident or crime? About the meaning of face injuries inflicted by blunt force. *Forensic Sci Res* 1:14–21
- Salonen EM, Koivikko MP, Koskinen SK (2010) Violence-related facial trauma: analysis of multidetector computed

- tomography findings of 727 patients. *Dentomaxillofac Radiol* 39:107–112
34. Eggensperger N, Smolka K, Scheidegger B, Zimmermann H, Iizuka T (2007) A 3-year survey of assault-related maxillofacial fractures in central Switzerland. *J Craniomaxillofac Surg* 35:161–167
 35. Hartzell KN, Botek AA, Goldberg SH (1996) Orbital fractures in women due to sexual assault and domestic violence. *Ophthalmology* 103:953–957
 36. Beck SR, Freitag SL, Singer N (1996) Ocular injuries in battered women. *Ophthalmology* 103:148–151
 37. Clark TJ, Renner LM, Sobel RK, Carter KD, Nerad JA, Allen RC et al (2014) Intimate partner violence: an underappreciated etiology of orbital floor fractures. *Ophthal Plast Reconstr Surg* 30:508–511
 38. Thomas R, Dyer GSM, Tornetta P Iii, Park H, Gujrathi R, Gosangi B, et al. Upper extremity injuries in the victims of intimate partner violence. *Eur Radiol*. 2021;31: 5713–5720.
 39. Khurana B, Sing D, Gujrathi R, Keraliya A, Bay CP, Chen I et al (2021) Recognizing isolated ulnar fractures as potential markers for intimate partner violence. *J Am Coll Radiol* 18:1108–1117
 40. Khurana B, Loder RT. Injury patterns and associated demographics of intimate partner violence in older adults presenting to U.S. emergency departments. *J Interpers Violence*. 2021; 8862605211022060.
 41. Ruiz-Pérez I, Plazaola-Castaño J, Vives-Cases C. Methodological issues in the study of violence against women. *J Epidemiol Community Health*. 2007;61 Suppl 2: ii26–31.

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